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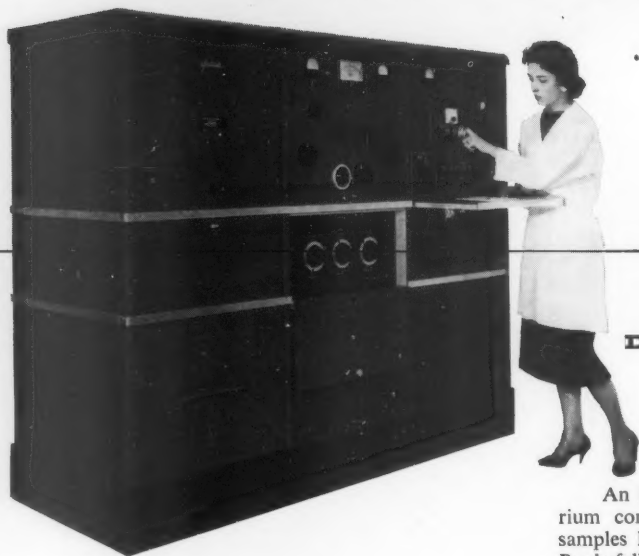
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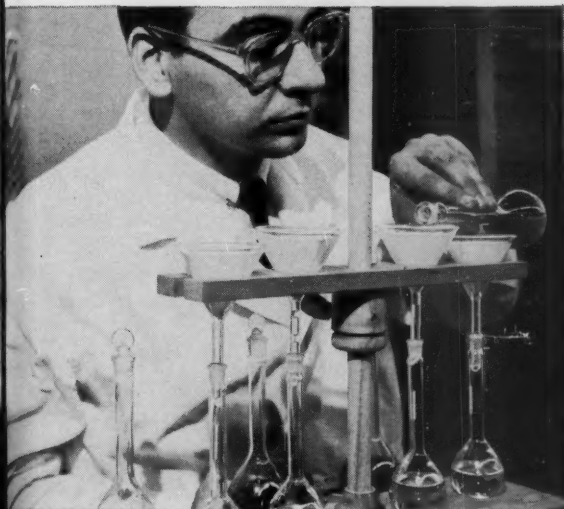
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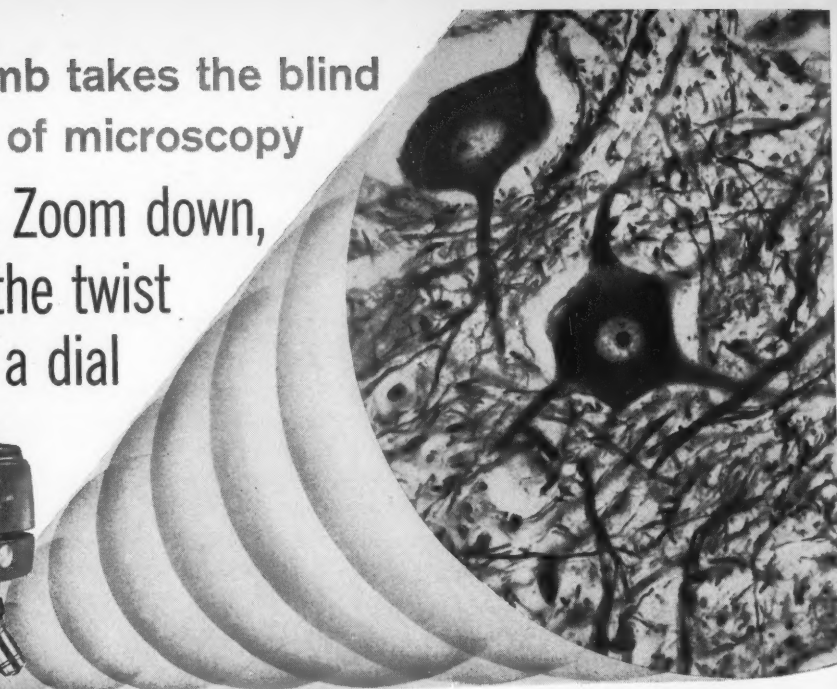
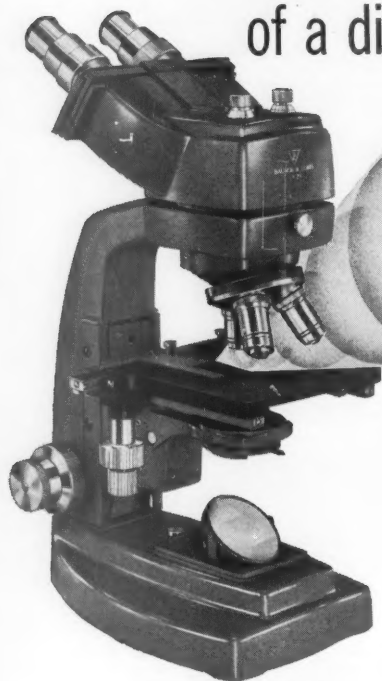
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## Smooth Sailing

International scientific meetings offer an unparalleled stimulus to scientific progress; they assemble the world's most notable investigators to their mutual benefit; and they are especially stimulating to the younger scientists of the host country whose international contacts are more limited than those of their older colleagues.

Owing to our immigration laws and to their interpretation by the State Department in the past, successful international meetings have been difficult to arrange in the United States. Some foreign scientists have objected to the difficulty of obtaining visas, the extensive questionnaire that was required, the fingerprinting requirement, and their liability to be put in an ineligible category. Another difficulty has arisen from the travel restrictions imposed upon Soviet nationals, which have made it difficult to find suitable places to meet and routes by which the Russians could reach them.

But happily the last few years have seen some sharp changes in policy. Both Congress and the State Department have taken steps to ease visa difficulties, and the State Department is willing to open up restricted areas for international meetings. The change in attitude and policy became evident when Congress gave the State Department the right to waive the fingerprinting requirement in 1957. Additional small steps have been taken since. Only this spring the lengthy written questionnaire, which seemed to applicants to pry unnecessarily into their past and to be a test of their memory for their past affiliations and whereabouts in minute detail, was eliminated.

A more important change has been made in the interpretation of eligibility. The law governing immigration designates certain categories of persons as ineligible for visas, but it also provides for waiver of the provisions (except for saboteurs and espionage agents) by the Attorney General. Formerly the question of a waiver was seldom raised; now it is. The consul is more likely now to refer a case to the Department, and the Department is now more likely to ask the Attorney General to authorize a waiver. Thus a scientist who is invited to attend a meeting here or a scientist in good standing who wants to come on his own initiative will find his chances for success much better than in the recent past.

The other main difficulty that has beset international meetings in the U.S. is the imposition of travel restrictions on Soviet nationals. These restrictions were set up by the State Department in 1955 in response to the long-standing Soviet practice of closing large areas of the U.S.S.R. to foreigners. Since parts of every state and of most cities are on the restricted list, a meeting that Russians could attend was precluded unless special concessions were made. The State Department now makes such concessions for international meetings: meetings may be held in restricted areas, and Russians may visit sites connected with the official program. Restrictions on travel to and from the meetings are similarly relaxed.

The next big international meeting scheduled for the U.S. is that of the International Astronomical Union, to be held in Berkeley next August. This will put the new practices to the test. So far all preliminary arrangements have gone well, and a large international attendance, including about 100 from the Soviet Union, is expected. If the Berkeley meeting continues to enjoy smooth sailing—and there is every indication that it will—the outlook for future international meetings in the U.S. will be greatly improved—G.DuS.



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## CURRENT PROBLEMS IN RESEARCH

Genetics of Mammalian  
Sex Chromosomes

Mouse studies throw light on the functions and on the occasionally aberrant behavior of sex chromosomes.

Liane Brauch Russell

In the past two years or less there has been a veritable explosion of knowledge in the field of mammalian cytogenetics, and a great many of the important findings concern the sex chromosomes, particularly in the mouse and in man. Much of the sudden progress can be attributed to recent advances in cytological techniques, and this is particularly true in man. In the mouse, however, it is the combination of cytological analysis with genetic experimentation, and, in many cases, even the latter by itself, that has yielded several exciting results. The genetic work would not, of course, have been possible before the discovery of useful sex-linked marker genes and of other genetic tools which have become available only in relatively recent years.

Discussions in this article focus primarily on the results of experimental work in the mouse, with special emphasis on new and hitherto unpublished findings. No attempt is made to review the voluminous literature on sex-chromosome anomalies in man, but evidence from this literature is cited wherever it helps in the presentation of a well-rounded picture. The findings discussed shed light on the functions of the sex chromosomes, both with respect to sex

determination and with respect to other actions, and on the mechanisms by which anomalies in chromosome number come about.

## Sex Determination

With the exception of a few species (discussed below), mammals have an XX-XY type of sex-chromosome mechanism, the male being the heterogametic sex. *Drosophila melanogaster*, too, has such an XX-XY mechanism, and in that species it has been known for over 30 years that sex determination is the result of a balance of female determiners on the X chromosome and of male determiners on the autosomes, the Y chromosome being inert (although necessary for male fertility). Only two years ago it was shown that mammalian sex determination is not of the *Drosophila* type. Specifically, the Y chromosome, instead of being inert, is strongly male-determining. In this respect, therefore, the mammalian system resembles that of the plant *Melandrium*.

The male-determining property of the Y chromosome was demonstrated in the mouse by combined genetic and cytological evidence which indicated that animals with the XO sex-chromosome constitution were normal and fertile females (1, 2). These females

were detected by virtue of the fact that they exhibited the phenotypes normally produced by certain sex-linked marker genes in males only. Breeding experiments (which, in cases where the phenotype was sublethal, involved ovarian transplantation) ruled out several of a number of possible alternative hypotheses and pointed strongly to the XO explanation. Final evidence for the XO hypothesis was provided by the cytological data, which indicated that the exceptional females had 39, instead of 40, chromosomes.

Almost simultaneously with our reports of the mouse experiments, there appeared in the literature reports of parallel findings in the human species. Thus, Ford *et al.* (3) found the XO sex-chromosome constitution in a female suffering from gonadal dysgenesis, and Jacobs and Strong (4) demonstrated the association between the XXY constitution and the Klinefelter syndrome (small testes, variable endocrine disorders). Since then, a great many more cases of both of these conditions have been reported. Chromatin-positive Klinefelter males, presumably XXY, occur relatively frequently in human populations (5). On the other hand, the XXY type had not been found in the course of the XO experiments in the mouse, even though the markers used in crosses for the detection of XO would, in most cases, also have led to detection of XXY. When, for some time thereafter, subsequent experiments also failed to yield this type, we concluded that either XXY mice occurred very rarely or that they were, for one of several reasons, undetectable. Thus, XXY might be female, or a female-like intersex; or XXY might be inviable; or the expression of the sex-linked markers used might be altered by the presence of the Y.

Doubts concerning detectability have now been dispelled by our recent finding of an XXY mouse in crosses marked by sex-linked genes. The XXY constitution, detected by genetic means, has been verified by cytological studies (6) (Fig. 1). The exceptional animal is

The author is on the staff of the Biology Division, Oak Ridge National Laboratory, Oak Ridge, Tenn.

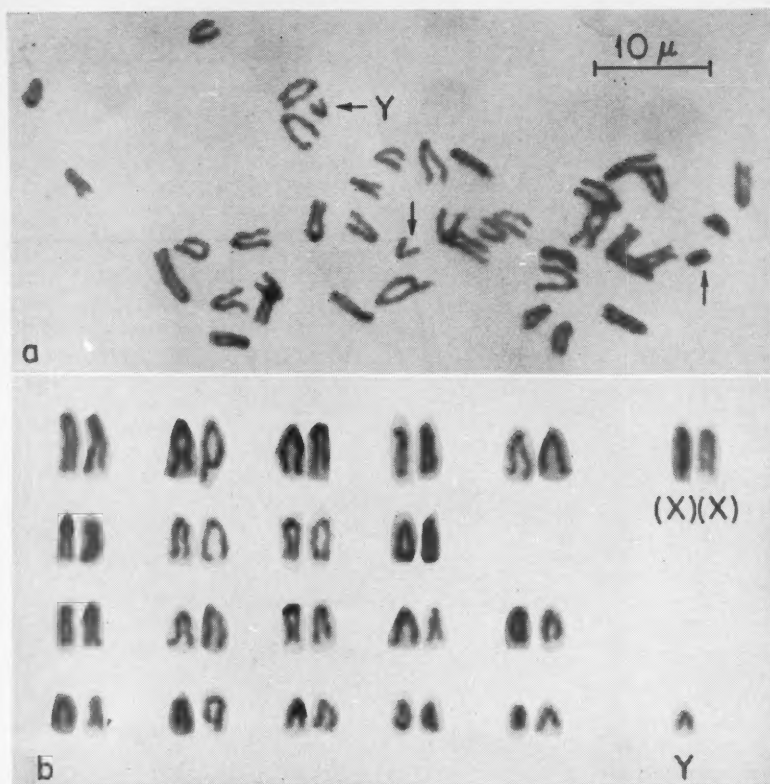


Fig. 1. Chromosomes of a mouse presumed, on genetic evidence, to be XXY. The cytology shows that this is, indeed, the case. (a) A metaphase cell in tissue culture derived from tail biopsy. There are 41 chromosomes. The Y chromosome is labeled. The unlabeled arrows indicate the smallest autosome pair. (b) The chromosomes of the same cell arranged in pairs, showing the presumed X-chromosome pair and the Y chromosome. [From Russell and Chu (6)]

viable, of normal size and male phenotype. It shows normal male mating behavior, but is apparently sterile. Its genotype is  $+/Ta/Y$ , and the expression of the marker  $Ta$  (= tabby) is not affected by the Y. Evidence derived from this animal strengthens an earlier report of a presumed XXY mouse (7) for which no cytological proof could be obtained because of the animal's untimely death.

In summary, then, it can be said that, both in the mouse and in man, XO is female or female-like, and XXY, male or male-like—clearly the opposite from *Drosophila*, where XO is male and XXY is female. In man, the deviation of the chromosomally aberrant individuals from sexual normality may be somewhat greater than in the mouse. On the other hand, this difference between the species may be only an apparent one, since, as has been pointed out (8), the more extreme cases among

human XO and XXY individuals would selectively come to the attention of medical investigators. In any case, it is quite clear that, far from being inert, the Y chromosome in mammals is strongly male-determining, a conclusion that has not been altered by the discovery, during the past year, of several aberrant sex-chromosome types in man, in addition to XO and XXY (for example, XXX, XXXY, XXXX, and XXXYY).

Not all mammals have the classical XX-XY sex-chromosome mechanism. The few exceptional species (among the well over 200 that have been studied cytologically) have recently been discussed by White (9). In three or four species, the male is  $XY.Y_2$ . Five other species had been reported to have XO males. If true, this would have indicated that male determination by the Y chromosome, as demonstrated in mouse and man, did not occur in all

mammals. However, White gives reasons for suggesting that, in at least some of the exceptional species, the Y is not really lacking but is present in a fused state. His general conclusion is "that the Y is an indispensable part of the mammalian sex-determining mechanism . . . and that it has probably not been lost on any occasion in mammalian evolution."

The demonstration that the Y is strongly male-determining has given us a basic insight into mechanisms of mammalian sex determination, but many questions remain. Are there male determiners also on the autosomes? How are the female determiners distributed? It seems improbable, from the available evidence that the X is strongly female-determining—that is, that female determiners are preferentially located on the X; for, if this were the case, both XO and XXY should be much more in the direction of intersexuality than they actually are. In the mouse, at least, it is not necessary to assume any female determiners at all on X, since the slight difference between XO and XX can be explained in terms of general vigor rather than of amount of "femaleness"; and the sterility of XXY could also be due to dosage phenomena of genes not necessarily directly concerned with sex determination. Thus, it is conceivable that in XXY males there are disturbances due to the presence of gene products of two sets of certain sex-linked genes in a Y-determined male developmental system which is normally in harmony with a smaller quantity of such gene products (10). It is also possible that X and Y have a short homologous region and that sterility may be the result of imbalance due to trisomy for this region.

#### Genetic Content of Y and X

The fact that the Y chromosome in mammals is so strongly male-determining indicates that it is not genetically empty. Yet, no other genes are definitely known to be located on the Y, although some are suspected. In the mouse, the so-called Eichwald and Silmser effect—that is, the rejection of within-strain tissue grafts when the donor is male and the recipient female—has been explained on the basis of Y-linked genes controlling antigenic differences (11). No other Y-linked genes, however, are known, in spite of

the fact that the conditions for both the induction and the detection of such mutations have been most favorable. In man, the formerly classical case of completely Y-linked inheritance, the "porcupine man," has recently been shown to be false, and the evidence for Y-linkage is considered incomplete in the case of other traits often assumed to show this kind of inheritance (12).

Partially sex-linked genes (presumably carried on portions of X and Y which are homologous to each other) have been reported in man, but, recently, doubt has been thrown on the reliability of the evidence (13). In the mouse, too, earlier reports of partial sex linkage have not been verified by more recent results. It may be that the homologous portions of X and Y are extremely short, as seems also indicated by cytological observations which reveal end-to-end pairing of the X and Y in the first meiotic division of the male mouse (14). The Y is the shortest of all chromosomes in the mouse (6) and in most primates (15). In man it is among the three shortest (16).

In contrast to the Y, the X chromosome bears a number of genetic factors. In the mouse, about 20 sex-linked mutations have occurred, more than half of them at this laboratory. A curious finding, however, is that the majority of the X-linked mutations are associated with a particular phenotype—namely, a dominant mottling of the fur—and are usually lethal in the male. Several of these "mottling" mutations have been located at the same, or approximately the same, spot on the X chromosome, and it is not inconceivable that they represent some type of chromosomal change rather than true gene mutations.

### V-type Position Effect

One interesting discovery made at this laboratory in the last few years is that the X chromosome of the mouse, when it is involved in certain chromosomal rearrangements, has the power to produce so-called variegated-type (or "V-type") position effects (17). V-type position effects have been known for years in *Drosophila* (18) but had never been demonstrated in any other animal. At least four of them are now known in the mouse (19, 20).

The best-studied case of V-type position effect—that involving the brown

locus—is used as an example in the discussion that follows (see Fig. 2). Experimental findings indicate that this position effect is probably the result of a reciprocal translocation between the X chromosome and chromosome 8, which bears the brown locus. That is, it is assumed that these two chromosomes have exchanged pieces, so that the brown locus—which carries the normal, or "wild-type," allele (+)—has come to lie in the vicinity of a piece of X chromosome. Normally, this + allele is completely dominant over the gene *b* (brown), so that the combination of + in one chromosome and *b* in the homolog gives a wild-type animal. However, when the + gene has been transposed to its new position near a piece of X chromosome, its action is impaired, or made uncertain, in some of the somatic cells. Consequently, with *b* present in the homologous chromosome, certain regions of the body are brown, even though the animal is only heterozygous for the recessive

*b* gene. The random mingling of brown and wild-type regions produces what is called, in accordance with *Drosophila* terminology, a variegated phenotype. Rigid proof of the genetic basis of this system has been sought in a number of ways that are too complex to go into here (19).

Two points are of particular interest for the purposes of this discussion. It has been shown in *Drosophila* that the basis for the great bulk of V-type position effects is change in location of a euchromatic gene to the vicinity of heterochromatin. Four cases of V-type position effect are known in the mouse, and in all four of them the gene in question has been brought to lie in the vicinity of a piece of X chromosome. Although the number of rearrangements of autosomes with other autosomes is presumably a large multiple of the number of rearrangements of autosomes with the X chromosome, no V-type position effect has yet been found that does not involve the X. The disproportional

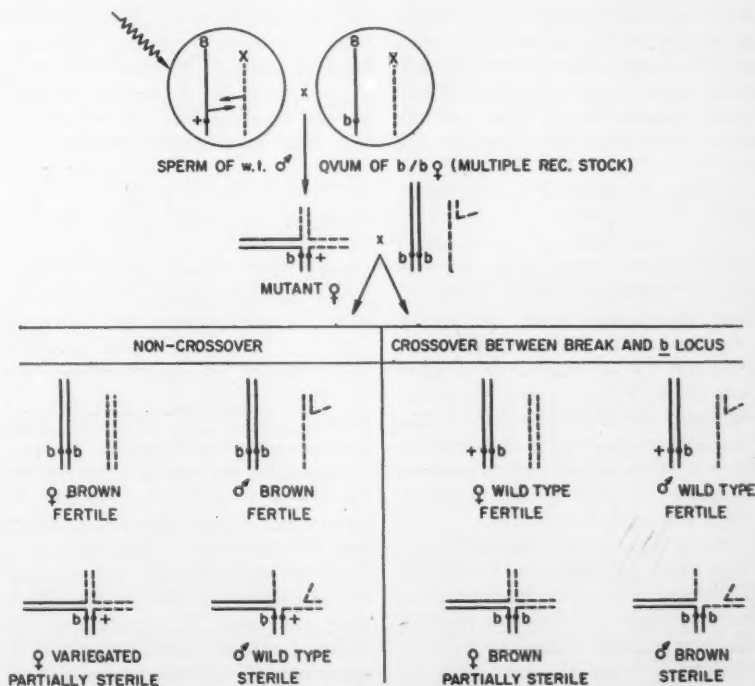


Fig. 2. Interpretation for the origin and transmission of position effect at the *b* locus. A reciprocal translocation between chromosome 8 (solid line) and the X chromosome (dashed line) has placed the wild-type allele of *b* (+ symbol) in the vicinity of a portion of the X chromosome. As a result of this new position, the action of the wild-type allele (+) is made "uncertain." Thus, + does not exert its normal dominance over *b* in all cells of the body, and the animal is variegated with brown. Note that this applies to females only (see text). A cross of such a variegated female and a normal brown (*b/b*) male produces eight types of progeny, as a result of segregation and crossing over. [From Russell and Bangham (19)]



Table 1. Dependence of the expression of the V-type position effect in the mouse on the number of X chromosomes present.

Constitution of chromosomes affected by rearrangement*	Sex chromosomes	Phenotype
8 <sup>x</sup> , X <sup>o</sup> , 8, X	XX	Variegated
8 <sup>x</sup> , X <sup>o</sup> , 8, Y	XY	Wild-type
8 <sup>x</sup> , X <sup>o</sup> , 8	XO	Wild-type
†	XXY	Variegated

\* The symbol 8<sup>x</sup> denotes a translocated chromosome composed of the centromere and the proximal portion of chromosome 8 plus the distal portion of the X chromosome. The composition of X<sup>o</sup> is the converse. The gene for brown (b) is present on the intact chromosome 8, while the rearrangement carries the wild-type allele.

† Rearrangement involving chromosome 1 and the X chromosome; also, intact chromosomes 1, X, and Y (20).

tionately great power of the X to produce such effects in the mouse would seem to indicate that there may be very little heterochromatin on the autosomes, while the X is strongly heterochromatic. The work of Ohno and his collaborators (21) brings cytological corroboration of this conclusion, which we drew on genetic grounds.

A second point of interest is derived from the finding that the rearranged position of the wild-type gene produces variegation in females only. Males bearing the rearrangement are nonvariegated—that is, wild-type (see Fig. 2, noncrossover progeny). In other words, in males the gene acts as though it were in its normal position.

In the early stages of our investigations, the most likely explanation for this sex difference seemed to lie in some suppressing action of the Y chromosome. In *Drosophila*, supernumerary Y's are known to suppress position effects, and it was, therefore, considered not impossible that, in the mouse, the single Y normally present in the male might be sufficient to suppress variegation. Recent results, however, lead to a different interpretation.

Certain females have occurred in our stocks which, although they carried the X-8 translocation, were wild-type rather than variegated. Breeding tests revealed that these animals lacked the intact X chromosome—that is, they were essentially XO (22). Thus, females with the translocation and an intact X (that is, carrying a total of two X's) are variegated; males with the translocation and the Y (carrying a total of one X) are wild-type; and females with the translocation but lacking the intact X (carrying a total of one X) are also

wild-type (Table 1). We therefore conclude that the presence of two X chromosomes is necessary for the expression of the V-type position effect. This conclusion has recently been confirmed by Cattanaich's finding of XXY males carrying an X-autosome rearrangement. As expected on the basis of our hypothesis, these animals were variegated (20).

A particularly interesting aspect of the foregoing conclusion—that the presence of two X chromosomes is necessary for the expression of what is presumably a heterochromatic effect—is that it can be related to a number of independent findings. In the hamster, Yerganian (23) has noted that females have one "predominant" X (which duplicates at the same time as the autosomes and has a euchromatic short arm) and one "retarded" X (which duplicates later in the cycle and has a heterochromatic short arm). The single X of the male is of the "predominant" type. A possible interpretation of this "triheterosomic scheme of sex determination" is that the X may assume temporary states that are determined by the company in which it finds itself. In man, cytological investigations on normal individuals, as well as on patients with an abnormal number of sex chromosomes, have indicated that the number of heteropyknotic chromosomes at somatic prophase, or of "sex-chromatin bodies" at interphase, is, in general, always one less than the number of X chromosomes present (24). These various findings permit the hypothesis that, in mammals, genetic balance requires the action of one X in a manner which precludes realization of its heterochromatic potentialities, so that only additional X's present assume the properties characteristic of heterochromatin.

Obviously, the results described for the V-type position effect fit into the framework of this hypothesis. When two X's are present, heterochromatic action of one is possible and produces the expression of the position effect, since the other X chromosome, inherited from the father, fulfills the requirement of nonheterochromatic action. When, however, no paternal X chromosome is present—that is, when the father provides a Y or no sex chromosome at all, as in the case of the XO—then the rearranged X must fulfill the nonheterochromatic functions and will not be able to produce the position effect.

## Aberrant Behavior of Sex Chromosomes

It is true in almost all fields of science that accidental or abnormal processes can shed much light on the nature of the normal mechanisms, which would otherwise remain hidden. In the case of the sex chromosomes it has already been shown how the abnormal sex-chromosome types have elucidated the manner of sex determination, and how, in conjunction with position effect studies, they have thrown light on gene action in the X chromosome. Naturally, the problem of how the abnormal sex-chromosome types are produced is of the greatest interest.

Abnormal sex-chromosome types may involve rearrangements of portions of sex chromosomes, and the study of these may turn out to be very profitable at a future time. The present discussion, however, is limited to the simpler types of aberrations on which some evidence is already available—namely, those involving changes in number of sex chromosomes, specifically the presence of a supernumerary sex chromosome or the absence of one of the sex chromosomes. The mechanisms that can be postulated as leading to these aberrations are grouped, for the purposes of this discussion, under the headings of nondisjunction and chromosome loss other than that resulting from nondisjunction (which, for the sake of brevity, is referred to below merely as "chromosome loss"). Nondisjunction may broadly be defined as the failure—for one of several possible reasons—of two members of a chromosome pair to separate to the two daughter cells. It results in one daughter cell's having both members of the pair and in the other cell's having neither. In discussing frequency of individuals with an abnormal number of sex chromosomes, "nondisjunction" and "chromosome loss" must therefore be considered separately, since nondisjunctional events are expected to produce, with equal probability cells with a supernumerary sex chromosome and cells lacking a sex chromosome, while chromosome loss (as a result, for example, of anaphase lagging) leads only to production of cells of the latter class.

Both nondisjunction and chromosome loss can, theoretically, occur in the meiotic divisions of either the father or the mother of the affected individual, or they can occur during



the cleavage divisions of the affected individual himself. A knowledge of the relative frequencies with which these various events take place is of considerable basic interest. The acquisition of this knowledge, however, is beset with practical difficulties. In the first place, the total frequency of abnormal sex-chromosome types is low. More important still is the fact that in only a few of them can there be any certainty about the causation of the abnormality. In human beings there is the added difficulty that the frequencies are distorted through the selection of patients. Nevertheless, it is already possible to draw certain conclusions, mainly from our data on the mouse, gathered during studies in which, using five sex-linked markers, we have made dozens of different types of crosses for the elucidation of various problems.

### Theoretical Expectations

Figure 3 shows schematically the various possible divisions at which nondisjunction of the sex chromosomes can occur in meiosis, and the gametes that are produced. The subscripts 1 and 2 distinguish the centromeres of the two maternal X chromosomes. It should be noted that any sex-linked markers present may have changed places as a result of crossing over (for example,  $X_1X_2$  may be homozygous, rather than heterozygous, for a sex-linked marker). The four different types of abnormal sperm, on fertilizing X-bearing eggs, would produce  $X^M X^P Y$ ,  $X^M O$ ,  $X^M X^P X^P$  and  $X^M YY$  zygotes (where the superscripts  $M$  and  $P$  designate maternal and paternal derivation, respectively, of a given X chromosome). Abnormal eggs can be fertilized by either X- or Y-bearing sperm, and thus there is a larger number of possible combinations:  $OX^P$ ,  $OY$ ; three of the  $XXY$  type ( $X_1^M X_2^M Y$ ,  $X_1^M X_1^M Y$ ,  $X_2^M X_2^M Y$ ); and three trisomic for X ( $X_1^M X_2^M X^P$ ,  $X_1^M X_1^M X^P$ ,  $X_2^M X_2^M X^P$ ).

Even though the diagram is elementary, it serves to illustrate a number of points that might otherwise be lost sight of in a discussion of relative frequencies. First, among the various types of abnormal zygotes expected, the XO type is, theoretically, the most frequent, since it can result from nondisjunction at either of the meiotic divisions and in either parent. There is the additional possibility that the relative frequency of meiotically caused

XO can be greatly increased by the occurrence of chromosome loss other than that resulting from nondisjunction. Second, if one compares the relative frequencies of  $X^M O$  and  $OX^P$ , it is obvious that, even if equal frequency of nondisjunction in the two sexes is assumed, the ratio will be 2:1, since the O gamete from the mother always has a half chance of combining with a Y chromosome, and this, as has been shown in the mouse (1), leads to a lethal combination. Third, it should be noted that all but a very few of the types of offspring resulting from the abnormal gametes listed in Fig. 3 can also result from events other than meiotic nondisjunction. Meiotic chromosome loss as a possible source of XO has already been mentioned. In addition, cleavage events, as is shown below, can result in XO's as well as in several of the other types of abnormal individuals.

Various possible abnormal sex-chromosome types resulting from events associated with the first cleavage are summarized in Fig. 4. The first of these events, chromosome loss, would again lead to the simple XO condition; and, again,  $OX^P$  is expected only half as frequently as  $X^M O$ , since half the cases of loss of  $X^M$  produce the inviable OY type. Both chromatid loss and nondisjunction would basically lead to mosaics. However, where one of the daughter cells is OY, this cell would probably fail to yield viable cell progeny, so that the resultant individual would be nonmosaic XY or XXY. Cell selection is, of course, possible in other

cases as well and can lead to normalcy, or at least to nonmosaicism, after a mosaic phase in early development. A similar result would be achieved by separation of the cell lines to form embryonic and extra-embryonic tissue, respectively.

Conversely, it is possible that normal tissue of a mosaic may be the secondary derivative in an individual having a basically abnormal number of sex chromosomes. Thus, in the case of a human XX/XO mosaic it has been postulated that the zygote was XO, and that XX cells were the result of nondisjunction in cleavage (25); and a human XXY/XX mosaic has been explained on the basis of loss of the Y in cleavage (26).

Although Fig. 4 shows only expectations concerning abnormal events that occur at the first cleavage, it can be used to predict the results of similar events occurring at later cleavages. Such later-cleavage events would always yield potential mosaics, with usually more than half the cells normal at the time of inception of the cell lines. Thus, chromosome or chromatid losses at a later cleavage would produce the same types of mosaics as those resulting from chromatid loss at the first cleavage (Fig. 4), except for differences in the proportion of cells establishing the cell lines. Nondisjunction at a later cleavage would lead to production of individuals with three types of cells. Naturally, the remarks made above, concerning the possibilities of cell selection and of separation of cell lines to form embryonic and extra-embryonic

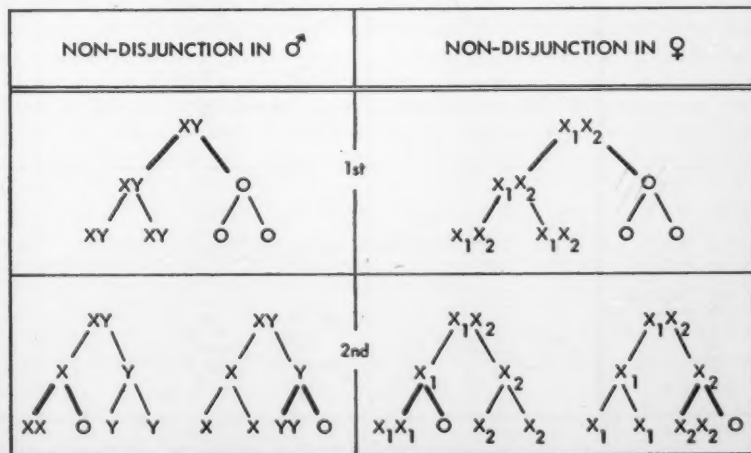


Fig. 3. Theoretical expectation concerning nondisjunction in meiosis. The cell division in which nondisjunction occurs is indicated by heavy lines.

tissue in initially mosaic individuals, apply to later-cleavage as well as to first-cleavage mosaics.

### Spontaneous Incidence of Abnormal Sex-chromosome Number

Of the several abnormal sex-chromosome types expected on theoretical grounds (Figs. 3 and 4), a large number have already been discovered in mammals. In the mouse, the  $X^0O$  and  $X^M X^P Y$  chromosome constitutions have been demonstrated genetically and cytologically (1, 2, 6, 7, 20), and  $OY$  has been shown to be prenatally lethal (1). Animals of the  $OX^P$  type have been reported (7), but it is not certain whether these were of primary occurrence or the offspring of a mating of undetected primary  $X^M O$ . In man, also, several cases of  $X^M O$  but only a very doubtful one of  $OX^P$  are on record (5). Human  $XXX$ 's have been reported, but it is not known whether these are  $X^M X^P X^P$  or  $X^M X^M X^P$ . All cases of  $XXY$  analyzed in man have been of the  $X^M X^M Y$  type (5). In addition to these simple types of sex-chromosome anomalies, many others (such as  $XXX$ ,  $XXXX$ , and  $XXYY$ ) and many mosaics, including some of those outlined in Fig. 4, have been reported in man. No sex-linked markers were available in these cases, and they cannot be reviewed in detail at this time.

The only condition which gives proof that a particular instance of nondisjunction has occurred in meiosis rather than in cleavage is the presence of both of the sex chromosomes of one parent in the offspring. This condition exists in  $X^M X^P Y$ . It also exists in  $X^M X^M Y$  and  $X^M X^M X^P$ , provided the two  $X^M$  chromosomes differ in their genetic markers. Actually, it is doubtful whether  $X^M X^M X^P$  would be detectable with markers available in the mouse at this time. The  $XXY$  anomaly was expected to be detectable, but only if the animal was viable and male (or male-like) and if the presence of the  $Y$  did not affect the expression of  $X$ -linked markers. Our recent discovery of an  $X^M X^P Y$  male (6), mentioned above, has now shown that these conditions are met. Since both  $X^{Ta}$  and  $Y$  are known to have been contributed by the father, this exceptional animal is actually the only mammal reported to date in which the stage of nondisjunction can have been no other than the first meiotic division in a presumably normal male. In man, cases of Klinefelter's syndrome in which the derivation of the  $X$ 's is marked by the gene for color blindness are of the  $X^M X^M Y$  type (5), with both  $X^M$  chromosomes bearing the same marker. Such individuals can be the result of nondisjunction at any one of three stages: in the second meiotic division of the mother; in the first meiotic division combined with a cross-

over (27); and in the first cleavage (see Fig. 4).

Comparisons of the frequencies of the various spontaneously occurring sex-chromosome anomalies in the mouse lead to a number of interesting conclusions. Data for these comparisons, some of which are summarized in Tables 2 and 3, come from a large number of crosses in which five sex-linked markers were used in various combinations and in  $XX \times XY$  as well as  $XO \times XY$  matings. Two comparisons that have been made are between the frequency of animals in which a paternal sex chromosome is lacking ( $P^-$ ) and those in which there is an extra paternal sex chromosome ( $P^+$ ), and between the frequency of animals in which a maternal sex chromosome is lacking ( $M^-$ ) and those in which a paternal sex chromosome is lacking ( $P^-$ ).

Table 2 summarizes results from 16 crosses in which simultaneous detection of  $P^-$  and  $P^+$  events was possible. The estimated frequency of occurrence (columns 6 and 7) has been calculated by taking account of the fact that detectability of one or the other event is only  $\frac{1}{2}$  in some crosses (columns 1 and 2). The single  $P^+$  event is the  $X^M X^P Y$  male mentioned above. Unfortunately for the clarity of Table 2, this animal occurred in an experiment in which postfertilization stages were irradiated (see below). However, its

	CHROMOSOME LOSS	CHROMATID LOSS	NON-DISJUNCTION
XY ZYGOTE	$\textcircled{X^M} Y \rightarrow OY \text{ DIES}$	$\textcircled{X^M} Y \rightarrow \frac{OY}{X^M Y} \rightarrow X^M Y \text{ } \sigma$	$\begin{array}{ c } \hline X^M Y \\ \hline X^M Y \\ \hline \end{array} \rightarrow \frac{OY}{X^M X^M Y} \rightarrow X^M X^M Y \text{ } \sigma$
	$X^M \textcircled{Y} \rightarrow X^M O \text{ } \text{f}$	$X^M \textcircled{Y} \rightarrow \frac{X^M O}{X^M Y} \text{ } \text{f}$	$\begin{array}{ c } \hline X^M Y \\ \hline X^M Y \\ \hline \end{array} \rightarrow \frac{X^M O}{X^M Y Y} \text{ } \text{f}$
XX ZYGOTE	$\textcircled{X^M} X^P \rightarrow OX^P \text{ } \text{f}$	$\textcircled{X^M} X^P \rightarrow \frac{OX^P}{X^M X^P} \text{ } \text{mos. } \text{f}$	$\begin{array}{ c c } \hline X^M & X^P \\ \hline X^M & X^P \\ \hline \end{array} \rightarrow \frac{OX^P}{X^M X^M X^P} \text{ } \text{mos. } \text{f}$
	$X^M \textcircled{X^P} \rightarrow X^M O \text{ } \text{f}$	$X^M \textcircled{X^P} \rightarrow \frac{X^M O}{X^M X^P} \text{ } \text{mos. } \text{f}$	$\begin{array}{ c c } \hline X^M & X^P \\ \hline X^M & X^P \\ \hline \end{array} \rightarrow \frac{X^M O}{X^M X^P X^P} \text{ } \text{mos. } \text{f}$

Fig. 4. Theoretical expectation concerning first-cleavage events that can result in sex-chromosome anomalies. Lost chromosomes or chromatids are encircled. In the case of nondisjunction, the possible groupings of one and three chromosomes, respectively, are indicated by divisions of the squares. Mosaic, *mos.*; hermaphrodite, combined symbols for male and female. A wavy line separates the two genotypes in mosaics.

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Table 2. Frequencies of mice lacking a paternal sex chromosome (P-) and of mice having an extra paternal sex chromosome (P+) (combined data from 16 different types of crosses in which simultaneous detection of these events was possible).

Detectability		Animals observed (N)			Corrected frequency (%) <sup>a</sup>	
P-	P+	Total	X <sup>M</sup> O	X <sup>M</sup> X <sup>P</sup> Y	P-	P+
1	1	1819	17	0	0.93	0
½	½	3660	11	0	0.60	0
½	1	350	1	0	0.57	0
Radiation experiment <sup>†</sup>						
1	1	539‡	17§	1		
Totals		5829	29		0.76	0.02
		6368		1		

<sup>a</sup> Estimated frequency of occurrence calculated by taking account of detectability, which, in some crosses, is only ½. <sup>†</sup> Irradiation on day 0 after fertilization (see Table 4). <sup>‡</sup> Excluded in calculating total frequency of spontaneous P- but included in calculating frequency for spontaneous P+ (see text). <sup>§</sup> Excluded in calculating total frequency of P-.

chromosome constitution rules out radiation as the cause of the XXY anomaly. [Naturally, the irradiated group with its 17 P- events, most or all of which could have been the result of irradiation, was not included in calculating the frequency of spontaneous occurrence of P- (Table 2, totals)]. While it cannot be stated with any degree of certainty that the ratio of P- to P+ is actually 38 (a value based on only one occurrence of P+), it is quite clear that the ratio is, indeed, quite high.

Table 3 summarizes data from eight crosses in which genetic markers were present for the detection of both M- and P- events. In a population in which 13 spontaneous occurrences of P- could be detected, there were no cases of M-. For comparison, data from the radiation experiment are also shown in Table 3.

Not only spontaneous M- but M+ cases also are lacking among anomalies discovered to date. They could have been found among 4711 offspring from nine types of crosses in which M+ events resulting from nondisjunction in the first meiotic division are theoretically detectable with a probability of up to 50 percent. [Half of the M+ events would presumably go unrecognized as a result of the X<sup>M</sup>X<sup>M</sup>X<sup>P</sup> type being nondetectable with the markers available at this time. In addition, if, as a result of crossing over, X<sup>M</sup> becomes homozygous for the markers carried by the mother, some of the X<sup>M</sup>X<sup>M</sup>Y animals, too, would escape detection. Altogether, in our crosses, the detectability of M+ from first-meiotic nondisjunction is ½ (1 - ½ c.o.), where c.o. is the frequency of crossing over between the X centromere and the marker used, an as yet unknown quantity.] Thus, although the present indications are that M+ events are very infrequent (if, indeed, they occur at

all), it cannot yet be stated with certainty that M+ is even rarer than P+.

Before discussing the implications of the frequency comparisons, it is necessary to present the results of investigations designed to test whether the frequency of XO mice could be altered by artificial means.

#### Induction of Abnormal Sex-Chromosome Number

Evidences of nonrandomness in the original XO data in the mouse (1, 2) (for example, the finding of XO litter mates) suggested that cleavage events might be very important in the spontaneous origin of the XO anomaly and led us to attempt to increase the frequency of XO individuals by irradiation during cleavage stages. The results of this experiment are summarized in Table 4. A preliminary report was presented earlier (28).

With appropriate sex-linked markers, instances of both maternal and paternal sex-chromosome loss could be detected. We were able to show that the frequency of XO individuals could be significantly increased by irradiation on the day of fertilization (day 0 in Table 4). Since, in the mouse, almost a full day elapses between fertilization and the first cleavage, it was possible to test the effect of irradiation at

various times during that day. The frequency of XO mice was highest after irradiation at the earliest time tested (11:00 A.M.) and somewhat lower when animals were exposed later in the day. Irradiation during subsequent cleavages (1½ to 4½ days after fertilization) or at postcleavage stages was ineffective in increasing the frequency of XO individuals. One point of considerable interest was that exposure at 11:00 A.M., the stage at which irradiation yields the highest frequency of induced XO mice, produced some animals lacking the maternal X, an event which has not yet been observed to occur spontaneously (see the discussion above and Table 3) or from irradiation at other stages (Table 4).

None of the XO mice obtained in this experiment gave the appearance of mosaicism. Moreover, when progeny was obtained from the XO animals as well as from many phenotypically non-exceptional animals, in an attempt to detect possible gonadic mosaicism, the results were negative. We thus conclude tentatively that we have induced chromosome loss prior to the first cleavage. Although four, and in some cases five, autosomes were also marked, no autosomal losses were detected. It may be assumed that such losses, if they occur, are cell-lethal.

#### Mechanisms That Produce Abnormal Numbers of Sex Chromosomes

That nondisjunction of sex chromosomes can occur in meiotic divisions was shown by our discovery of an X<sup>M</sup>X<sup>M</sup>Y animal from an X<sup>M</sup>X<sup>M</sup> × X<sup>M</sup>Y mating. However, the absence, to date, of both M+ and M- would seem to indicate that nondisjunction in the first meiotic division of the female is very rare, if not nonexistent; and the low frequency of X<sup>M</sup>X<sup>P</sup>Y, as compared with X<sup>M</sup>O, suggests that, in the male too, nondisjunction in the first meiotic division is a rare occurrence. It is obviously

Table 3. Frequencies of mice lacking a paternal sex chromosome (P-) and of mice lacking a maternal sex chromosome (M-) (combined data from eight different types of crosses in which simultaneous detection of these events was possible).

Detectability		Animals observed (N)			Corrected frequency (%) <sup>a</sup>	
P-	M-	Total	X <sup>M</sup> O	OX <sup>P</sup>	P-	M-
1	½	1271	13	0	1.02	0
½	½	67	0	0	0	0
Total		1338	13	0	0.99	0
Radiation experiment <sup>†</sup>						
1	½	425	14	4	3.29	1.88

<sup>a</sup> Estimated frequency of occurrence calculated by taking account of detectability, which, in some crosses, is only ½. <sup>†</sup> Irradiation at 11:00 A.M. on day 0 after fertilization (see Table 4).



Table 4. Frequencies of sex-chromosome loss after irradiation at various postfertilization stages.

Stage irradiated		Animals observed (N)			Corrected frequency (%) <sup>a</sup> of sex-chromosome loss
Day	Hour	Total	X <sup>MO</sup>	OX <sup>P</sup>	
0†	11 A.M.	425	14	4	5.2 4.5-4.6 1.4
0	12:30-2 P.M.	44	2	0	
0	3:30 P.M.	70	1	0	
1½ to 13½		402	2	0	0.5 1.4
Control		420	6	0	

<sup>a</sup> Estimated frequency of occurrence calculated by taking account of the fact that only half of all losses of maternal X are detectable. † Day 0 designates the day on which the vaginal plug is found.

necessary to look for other events that might account for the relatively high frequency of XO, specifically X<sup>MO</sup>.

Events yielding X<sup>MO</sup> but not X<sup>MX</sup>Y can occur during meiosis (for example, anaphase lagging, or nondisjunction in the second division, which would also produce presumably nondetectable XX and YY gametes); or they can occur following fertilization. Cleavage as a relatively frequent source of XO's in the mouse had already been suggested by the nonrandomness of the original XO data—for example, the finding of XO litter mates—and has now been implicated even more by the demonstration that the frequency of XO animals can be increased by irradiation shortly after fertilization. On the basis of cytological evidence, Ohno, Kaplan, and Kinoshita also believe nondisjunction to be more frequent at cleavage, since they found either one X or one Y in each of 1460 second-meiotic nuclei examined (29).

As was shown above, not only is X<sup>MO</sup> much more frequent than X<sup>MX</sup>Y, but X<sup>MO</sup> is also much more frequent than OX<sup>P</sup>. A hypothesis that would fit both of these results is that there exists a relatively high probability of loss of the paternally contributed sex chromosome some time between fertilization and completion of the first cleavage. Such a hypothesis is not unreasonable in the light of the observation (30) that, during that interval, the nuclear material contributed by the male undergoes considerably more changes than that contributed by the female, with respect to such factors as size of the pronucleus, number of nucleoli, and total nucleolar volume. If the paternally contributed nuclear material, in general, is indeed vulnerable at this stage, it is not inconceivable that there is increased probability that individual paternal autosomes, as well as X<sup>P</sup> or Y, will be lost. Such an event, however, would probably lead to the death of the individual, unless the maternally contributed homolog were present (or came to be present) in double dose—

an explanation which has been proposed to account for a certain class of spontaneous mutants in the mouse (31).

The hypothesis that it is the paternally contributed sex chromosome which is more easily lost at, or prior to, the first cleavage does not exclude the possibility that this event may be influenced by factors traceable either to the mother or to the circumstances of fertilization. For example, properties of the zygote cytoplasm that could be under maternal control, or that could be influenced by the interval between ovulation and fertilization, might in turn affect the behavior of chromosomes contributed by the male pronucleus. Explanations of this nature could account for the occurrence of XO litter mates (2), the nonrandom distribution of spontaneous primary XO mice among sibships (1), and the possibility that there may be "high XO" lines (1).

Although the foregoing discussion has applied to presumably nonmosaic types, it should be noted that sex-chromosome mosaics of various kinds have been reported in man, and that a few have been found (although not yet well studied) in the mouse. Such mosaics would, of course, result from postfertilization events, but not necessarily from the simple loss of a paternally contributed sex chromosome that has been discussed here.

### Summary

The great strides made during the past two years in the whole field of mammalian cytogenetics have, in particular, enlarged our knowledge of the role of the mammalian sex chromosomes. The following summary briefly lists the most recent discoveries in the mouse, where genetic findings have played a relatively greater role than in the other species of mammals.

The male-determining property of the mammalian Y chromosome, established earlier in mouse and man, has been further confirmed by the finding

of an XXY mouse, which was detected by genetic means and has been studied cytologically. This animal is a fully viable, phenotypically normal, though sterile, male. Since various doubts concerning detectability of the XXY type have been removed by the discovery of this animal, it can be concluded that the occurrence of XXY in the mouse is extremely rare.

It has been shown that the X chromosome of the mouse, when it is involved in certain chromosomal rearrangements, has the power to produce variegated-type position effects, a phenomenon formerly not observed in any animal except *Drosophila*. The fact that the X chromosome is involved in all four of the known cases of V-type position effect in the mouse indicates that it is strongly heterochromatic, while there may be little heterochromatin on the autosomes. Recent findings have shown that the presence of two X chromosomes is necessary for the expression of the position effect in one of them. This fact, when related to various cytological findings in other species, permits the hypothesis that, in mammals, genic balance requires the action of one X in a manner which precludes realization of its heterochromatic potentialities, so that only any additional X's present assume the properties characteristic of heterochromatin.

A variety of different findings sheds light on the mechanisms that may lead to the occurrence of individuals with abnormal numbers of sex chromosomes. The XXY mouse proves, by virtue of its sex-linked marker genes, that nondisjunction can occur in the first meiotic division of a normal male (a proof not previously provided by human cases of XXY, which could have been of different origin). However, first-meiotic nondisjunction is apparently very rare in males, and there is not yet any evidence that it ever occurs in females. Data from numerous types of crosses involving five sex-linked markers yield the following results: no cases of X<sup>MX</sup>Y or OX<sup>P</sup> have occurred to date; X<sup>MX</sup>Y ≪ X<sup>MO</sup>; OX<sup>P</sup> ≪ X<sup>MO</sup> (where the superscripts M and P designate maternal and paternal derivation, respectively, of the X).

The total frequency of XO individuals can be increased by irradiation shortly after fertilization. This treatment has yielded, in addition to X<sup>MO</sup>, several animals of the OX<sup>P</sup> constitution, a type that has not yet been found to occur spontaneously.

The various findings on spontaneous



and induced frequencies of mice with abnormal numbers of sex chromosomes lead to the conclusion that XO individuals are most often the result of events occurring after fertilization. Specifically, it is suggested that there exists a relatively high probability of loss of the paternally contributed sex chromosome some time between fertilization and the first cleavage (32).

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## Population and Politics in Europe

Demographic factors help shape the relative power of the communist and noncommunist blocs.

A. F. K. Organski

World population problems have attracted wide attention in recent years, but discussions of demography all too often skip over Europe with only a bare mention. True, Europe is not a demographic trouble spot today. Although the "population explosion" of which we hear so much originated in Europe, its force is spent and the continent has escaped unscathed, indeed enhanced, by the experience. Europe's population today is large and dense, more dense in fact than that of Asia, if population per square kilometer is considered (see Table 1), but population pressure in Europe offers no obstacle to economic development or political tranquillity. Nor is Europe's population growing as rapidly as that of the underdeveloped areas that fill us with concern. The annual rate of

increase from 1950 to 1958 was only 0.7 percent in Europe as against 1.8 percent in Asia, 1.9 percent in Africa, 2.1 percent in the Americas, and 2.3 percent in Oceania (1, Table 2). Already highly developed, Western Europe can easily absorb any increases that are likely to occur in the future. Those portions of Southern and Eastern Europe that are not yet developed are rapidly increasing the efficiency of their economies, and they, too, should be able to handle future increments in their population.

This does not mean, however, that demographic facts no longer affect the politics of Europe. Population trends, both past and present, have a direct effect upon the power position of European nations in relation to the rest of the world and in relation to each other, and this effect is the greater precisely because the economic and social organization of European na-

tions is such that population growth no longer presents a problem. Because most of the European nations are industrial or are industrializing rapidly, they can use their people for purposes of power, unlike the struggling underdeveloped nations, who may find their population growth a liability.

The relationship between population and politics in Europe is of long standing. In the laissez-faire century before World War I, demographic trends influenced European power, but political developments had little effect on demographic trends. Immense population growth, unplanned and uncontrolled, was crucial in making Europeans first in power in the world. Europe's population explosion provided the working hands to run the new industrial economies at home, the migrants to create European allies outside of Europe, and the administrators and soldiers to run far-flung empires that encompassed half the world's area and one-third of its population.

The population growth that had enabled Europe to reap such handsome political yields from its economic development slacked off in the 20th century. Birth rates dropped first in Western Europe, where the Industrial Revolution had started and where, in consequence, urban values, favoring small families, had had the longest time to become widespread and deeply entrenched, but as the century progressed, birth rates began to fall in Eastern Europe, too (2, pp. 12-13). Low birth rates, low death rates, and low or moderate rates of increase are facts of life today in most of Europe,

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Table 1. Population densities in Europe and Asia, 1958. [From 1, Tables 1 and 2]

Area	Population (per km <sup>2</sup> )
Asia	59
Indonesia	59
China	69
Philippines	80
Pakistan	91
India	121
Korea	138
Japan	248
Europe	85
France	81
Poland	92
Italy	162
West Germany	210
United Kingdom	213
Belgium	297
Netherlands	345

but one government after another has fought against these facts. In the 20th century, the relationship between population and politics had changed. Politics was trying to influence demographic trends.

Faced with a fall in birth rates and a potential decline in numbers, governments adopted policies designed to raise fertility. At the same time, however, political events of quite a different sort intervened to affect Europe's population, as wars and revolutions wiped out whatever gains pronatalist policies might have made and set loose a flood of new migration.

#### Pronatalist Policies

In view of the general concern over Europe's sagging birth rates, which fell during the depression years to a point where they endangered population growth and even promised population decline, it is perhaps surprising how few of the European nations adopted population policies and how inconsistent some of these policies were. England, for example, though greatly concerned, did nothing until after World War II, when it instituted a program of family allowances for children, more as a welfare measure than as an attempt to influence family size, for the allowances are far too small to encourage production of larger families (3). Hungary adopted a strong pronatalist policy in the early 1950's but abandoned it by 1960 (4, p. 193). Sweden and Bulgaria (4, p. 196) are examples of nations carrying out pronatalist and antinatalist measures at the same time. Russia has one of the most consistent pronatalist policies but for many years denied that its extensive program was designed to

affect population size. Nazi Germany, Fascist Italy, and contemporary France perhaps deserve the prizes for consistency, but the effectiveness of their policies is open to question.

However, before we pass too severe a judgment, it should be noted that framing a coherent policy in the field of population is extremely difficult, for the most effective means of achieving higher fertility may conflict with other values important to the society. In such cases, contradictory policies result. The Swedish government, for example, has refused to do anything that would infringe upon the individual's right to plan the size of his family. It has therefore eschewed any appeals to patriotism as a motive for increasing fertility and has refused to restrict the individual's right to practice birth control, sterilization, or even abortion, if health or economic necessity makes such steps desirable (5, p. 222). Following the lead of the Soviet Union, most of the eastern European nations have also legalized abortion, even though this runs contrary to the pronatalist intentions of some of these governments. The aim is apparently to safeguard the health of women who would otherwise turn to illegal abortionists, but the effect must surely be to increase the number of abortions and to reduce the number of births.

Pronatalist policies may be divided into four categories. These are (i) general social welfare policies to improve economic conditions for those wishing to have more children; (ii) specific measures, such as cash allowances and tax benefits, offering financial relief to large families; (iii) repressive measures to prevent the use of contraception, abortion, and sterilization; and (iv) measures to strengthen the position of mothers and housewives in society and to make a large family a matter of prestige. The three major population policies in Europe today—those of France, Sweden, and Russia—differ widely in the emphasis they place upon these various areas of action.

In France, population policy relies heavily upon repressive legislation and extensive judicial and police activity to prevent abortions and the use of contraceptives, and upon a system of cash allowances high enough to provide a real increment to the income of large families. The French program also includes marriage loans, prenatal allowances, birth grants, housing allowances and grants, reduced school

fees, and subsidized vacations for children of large families (6).

Sweden's program includes some specific measures, such as cash allowances, but the emphasis is on general social welfare policies to provide adequate income, housing, and medical care for all families, on the assumption that this will remove some of the obstacles that prevented Swedes of an earlier generation from having larger families. At the same time, however, Sweden has enacted a series of measures that are antinatalist in effect if not in intention. Abortion is permitted for physical, psychological, or economic reasons, contraceptives are on sale in every chemist's shop, and information on contraception is given as a part of secondary-school sex education. It is obvious that Sweden seeks larger families, but only if the children are wanted (7).

Russia's program is perhaps the most extensive. It includes a broad range of welfare measures, financial assistance, and honors for the mothers of large families. However, legislation preventing abortion and contraception has been eased in recent years. Free medical care is available to all, but particular care is reserved for mothers and children; "mother and child specialty" is one of the three basic specialties in which all Soviet physicians are trained. Free education through the university level further decreases the cost of raising children. Working mothers are guaranteed light work while they are pregnant, maternity leave with pay, time off to nurse their infants, and day-nursery service for small children. Tax benefits and cash payments favor large families, and the Soviet government honors mothers of large families with special medals and titles, running from Motherhood medals for mothers of five grown children up to the title of Mother Heroine, which goes to mothers of ten grown children, together with a special certificate from the Presidium of the Supreme Soviet of the U.S.S.R. (4, p. 179; 8).

A larger population is not, of course, a goal in itself, and all of the European nations concerned with population size have other, ultimate goals in mind: economic welfare, national power, and cultural survival. British and Swedish writers have expressed concern lest a declining population reduce investment opportunities and lead to economic stagnation and, eventually, to a lower standard of living (5, p. 124; 9, chap. 10, 11).

Considerations of power are more crucial, however, and have played a part in all of the pronatalist policies. These considerations were stated most clearly by the Germans and Italians. Joseph Goebbels declared: "If Germany wishes to fulfil her great national and international tasks . . . she needs hands. That is why the new regime encourages large families" (10).

Mussolini was even more frank: "To count for something in the world, Italy must have a population of at least 60 millions when she reaches the threshold of the second half of this century. . . . Let us be frank with ourselves: what are 40 million Italians compared with 90 million Germans and 200 million Slavs?" (11).

French population policy was motivated in large part by the fear of Germany's rapidly expanding numbers, and the French *Code de la famille* of 1939 may be viewed in part as an answer to Nazi Germany's earlier pronatalist policy in a sort of demographic armaments race. British officials were also well aware of the political implications of the nation's slowing rate of growth; royal commissions on migration and on population expressed the fear that Britain's ties with the Commonwealth nations would suffer if Britain's population did not grow rapidly enough to provide a steady stream of migrants to keep the populations of such nations as Canada, Australia, and New Zealand predominantly British in origin (9, pp. 125, 225, 133).

It is probable, though hard to prove, that considerations of power are at the root of Russia's population policy as well, for the Soviet Union needs manpower not only to make up her war losses and to staff her growing industries but also to fill her open spaces and to avoid being completely dwarfed by her giant ally and neighbor to the south.

Sweden, on the other hand, seems less interested in power than in cultural survival, and her population policy is designed to perpetuate Swedish culture as well as to maintain the nation's international standing. Alva Myrdal expressed the feeling in these words: "Our society is too good not to be preserved. . . . It is not going to be so stimulating to work for a national culture that is under liquidation. It is not going to be so satisfying to build up a social structure which our children are not going to inherit" (12). In a way, of course, a desire for cultural

survival underlies the pronatalist policies of all nations.

The effectiveness of European pronatalist policies is hard to judge. In theory, two measurements are required—an accurate measure of fertility after the policies have been put into effect and accurate knowledge of what fertility would have been if the policies had not been put into effect—but in the absence of an experimental situation, the second measurement is always lacking.

The case of Nazi Germany has been perhaps most thoroughly examined. In Germany, a sharp rise in the birth rate followed directly upon the introduction of pronatalist measures. Nazi officials, quite naturally, took full credit for the change, but it seems more likely that the rise in births was due to the return of economic prosperity and full employment, since an exceptionally high correlation (+.79) has been found between the monthly employment rate and the monthly birth rate 9 months later for the years 1931 to 1939 (13).

Sweden also experienced an increase in fertility accompanying the implementation of her population policy, the birth rate rising from 13.7 in 1934 to 20.6 in 1944. Since then, however, the Swedish birth rate has dropped steadily (it was back at 14.2 in 1958), although the pronatalist policies have been continued.

The experience in France is particularly interesting. There prewar policies were accompanied by a continued drop in the birth rate. However, the implementation of the *Code de la famille* coincided with an increase in fertility during the latter years of the war, and with the end of the war the French birth rate soared. France maintained a relatively high birth rate after the postwar baby boom had run its course in other western European nations. French expert Alfred Sauvy gives the credit to French policy (14), but it must be noted that the birth rate in the United States has also risen high and stayed high since World War II, without any deliberate population policy whatever.

### Wars, Revolutions, and Migrations

Any gains in European population won through governmental policies have been more than offset by losses due to political strife, for this bloodiest of all centuries has seen Europe wracked by two world wars, a civil

war, a revolution, and a number of smaller conflicts. The total losses in population are difficult to count, for they include not only war dead but also deaths from disease and malnutrition following in the wake of the wars, and "losses" attributable to the fact that a large number of births which would have occurred in peacetime did not occur in time of war. Estimates place the total cost in lives of Europeans (15) of the two world wars alone at well over 100 million. Russia alone suffered a staggering loss of some 71 million lives. Germany was the second largest loser, but her losses are estimated at only one-seventh of Russian losses. French and British losses combined were less than those of Germany.

Significantly, losses in Eastern Europe were greater in both wars than those in Western Europe, but the difference was especially great in World War II. Among the major powers, France suffered military losses in World War II of about 200,000. If one adds the deaths of civilians, deportees, and prisoners of war, the total reaches about 600,000, or less than half the comparable losses in World War I. In Britain, losses in all categories—military casualties, excess civilian deaths, and the deficit of births—were less than they had been in World War I. Russian losses, in contrast, were almost double what they had been in World War I, for the Soviet Union suffered an estimated 25 million war deaths and a deficit in births of 20 million as a result of World War II. The Soviet satellite nations in Eastern Europe had a loss from excess deaths alone of more than 6 million (2, p. 14; 16).

The difference in the magnitude of the losses of eastern and western European countries can be attributed in part to the shorter period of fighting in Western Europe. In addition, the slaughter by the Germans of their eastern European captives was much worse than anything that occurred in Western Europe.

Population deficits, however, are not the only demographic changes brought about by political conflict in Europe. War, revolution, revolt, and political persecution dislocated millions of Europeans, forcing them to migrate from one nation to another and resulting in a serious loss of population for Eastern Europe.

Again, exact figures are hard to come by, since many of these forced migrations were illegal and therefore



not counted, or since they took place in the midst of wars. However, the estimated total for refugee migration in Europe since World War I is in the neighborhood of 30 million people. This includes 1½ million refugees from the Russian Revolution, about ½ million Republican refugees from Spain (more than half of whom later returned home), and some 800,000 prewar refugees from Nazism in Germany, Austria, and Czechoslovakia.

However, nothing that went on before the war can compare with the displacement of at least 21 million people by World War II. As Hitler's armies advanced, millions of Europeans fled before them, while at least 8 million others who did not flee fast enough were shipped back to Germany as prisoners of war and slave laborers. In addition, Germany expelled over 2 million Poles, Slovenes, and inhabitants of Alsace-Lorraine from their territories to make way for German settlers. Then, as Germany began to lose the war and her armies began to retreat, the Nazis conducted a mass abduction of non-German civilians. German settlers, non-German collaborationists, and anticommunists from Eastern Europe went along with them voluntarily. By the end of the war, there were probably more than 12 million non-German displaced persons in Europe and about 9½ million German refugees from other territories crowded into Germany.

Territorial changes at the end of World War II further scrambled Europe's population, changing the allegiance of many Europeans even though they did not migrate, and altering the size of nations. Most seriously affected, of course, was Germany, which was split in half and which lost both territory and population. Not until 1953 did the total German population again reach the size it had been in 1939. West Germany today is again the largest nation in population size in Europe (unless one counts the Soviet Union), but Germany no longer towers over Britain in population, as it did before the war. Rumania lost more than 4 million people (a fifth of its population) through loss of territory; Poland suffered a net loss of 3 million. Today, Poland, Rumania, and Czechoslovakia all have smaller populations than they had in 1939.

As a net result of territorial changes and war losses, Eastern Europe as a whole (not including the U.S.S.R.)

lost 25 million people between 1938 and 1947 (2, p. 16), and the exodus from Eastern Europe continues. Since World War II, roughly 3.1 million East Germans have escaped to West Germany, and 190,000 Hungarians left Hungary at the time of the unsuccessful revolt.

Of particular interest and significance is the constant flow of Germans seeking refuge in West Germany and in West Berlin. The migration has been large enough to erase the natural gain in East Germany due to an excess of births over deaths, thus causing a steady decline in the total population of East Germany. In addition, the migration has affected the age structure, since a high proportion of the refugees are young, 40 percent of them being between the ages of 14 and 24 (2, p. 21). Politically, the exodus has been both frightening and dangerous to the East German regime, and the desire of the communists to see the Allies move from West Berlin surely reflects in part a desire to close the escape hatch from Eastern Germany (17). However, to the degree that the mi-

grants are motivated by a desire for higher living standards rather than a wish to escape totalitarianism, the migration should diminish somewhat if the presently low standard of living in East Germany rises.

### Size and Distribution of European Population

The flight from East Germany illustrates vividly the most important political legacy of World War II to Europe: the division of the continent into two opposing camps. This division is probably permanent, for it rests not only upon the obvious irreconcilability of the U.S.S.R. and the Western Powers; it is beginning to be grounded on something deeper than ideology—that is, upon the growing economic and military integration of the countries within each bloc.

Demographic factors play an important part in shaping the relative power of these two blocs, for population size is one of the important determinants of national power in the mid-20th century, although of course there are other important determinants as well (18). In population size, the halves are roughly equal. West of the Iron Curtain live some 302 million people, while east of the line live 97 million people, if Yugoslavia and the U.S.S.R. are excluded. However, if one adds to the Eastern bloc the 209 million people of the Soviet Union, the two regions are almost exactly equal in size (see Table 2).

This is not to say that the two areas are equal in power, for the West possesses an advantage in being far more developed economically, while the East possesses an advantage in consisting of fewer units, more closely tied together.

The economic superiority of Western Europe is clear. Western Europe, which was the first of all the regions in the world to industrialize, is today one of the richest areas on earth, with an aggregate wealth greater than Russia's and second only to that of the United States. Though rapid development in Eastern Europe may change this picture in the future, Western Europe today enjoys a clear superiority in capital goods, in annual production, and in living standards. These are great assets as far as international power is concerned.

The distribution of population

Table 2. Populations of communist and non-communist nations of Europe, 1958. [From 1, Table 1]

Nation	Population (millions)
<i>Noncommunist nations</i>	
Western bloc	
West Germany*	54
United Kingdom	52
Italy	49
France	45
Spain	30
Netherlands	11
Belgium	9
Portugal	9
Greece	8
Denmark	5
Norway	4
Luxembourg	0.3
Iceland	0.2
Neutral	
Sweden	7
Austria	7
Switzerland	5
Finland	4
Ireland	3
Total noncommunist†	302
<i>Communist nations</i>	
Russian bloc	
U.S.S.R.	209
Poland	29
Rumania	18
East Germany‡	17
Czechoslovakia	13
Hungary	10
Bulgaria	8
Albania	2
Neutral	
Yugoslavia	18
Total communist	324

\* Includes West Berlin. † Totals do not add up because of rounding. ‡ Includes East Berlin.



among the nations of Europe, however, confers an even more important advantage upon the communist nations, for there are only nine nations in communist Europe, while there are 18 non-communist European nations (not counting such tiny entities as Andorra, Liechtenstein, Monaco, San Marino, and Vatican City). Furthermore, the population of the European communist nations is heavily concentrated; two-thirds of the entire population is in the Soviet Union. Add the fact that, with the possible exception of Czechoslovakia, the U.S.S.R. is also the most economically advanced nation in communist Europe, and it is clear that Russia has an immense power advantage over her European neighbors.

This power advantage is most important in shaping the course of events in Eastern Europe, for it is almost completely because of Russian power that the satellite nations are in the communist camp at all. Russia has used her great preponderance of power, based in large part upon her preponderance of population, to force the economic integration of Eastern Europe. The military establishments of the various satellite nations are also undergoing integration.

The situation is quite different in Western Europe. Five of the noncommunist nations are not, politically speaking, in the Western camp at all (they are Austria, Finland, Ireland, Sweden, and Switzerland), and the remaining 13 are far from united. This lack of unity is due in part to the fact that no one nation of overwhelming size controls the area. Domination of Western Europe is shared by four middle-sized nations of roughly the same size. Britain, France, West Germany, and Italy, ranging in size from France's 45 millions to Germany's 52 millions (54 millions including West Berlin),

rule between them almost two-thirds of the population of Western Europe. No one of these nations has been willing to submerge its identity or even to sacrifice its national interests for the sake of western unity, and each of the four possesses the power to resist the wishes of the other three.

Future years will bring changes in the factors determining the relative power of Eastern and Western Europe. At present, the eastern European nations are growing in population at a higher rate than the western European nations, and in the short run, at least, they should increase their superiority in numbers over the western nations, in spite of a continuing drain of migrants fleeing from East to West.

The greatest change, however, will be in industrial strength, for here the East still has great gains to make. At present the western nations possess the advantage of highly industrialized economies, while many of the eastern satellites are still quite backward economically. However, modernization is being pushed very rapidly both in the satellites and in the Soviet Union. Economic progress will continue in the West, but for the more advanced nations the dramatic increase in power that comes with the first shift from an agricultural to an industrial economy lies far in the past. No future economic change is likely to bring with it another such sudden boost in power. Eastern Europe, on the other hand, has still to experience some of this sudden growth in power; we are currently witnessing such a growth in the Soviet Union, and it will soon occur in the satellites as well. Finally, it appears that regional unification is also proceeding more rapidly within the Eastern than within the Western bloc, and this trend, too, will probably continue.

There is, however, one way in which

Western Europe can use its population to increase its power. By reorganizing its people into fewer and larger political units, preferably into one United Europe, Western Europe would gain the power that comes from being a giant nation—power such as that possessed today by the United States and Russia, each of which, incidentally, has a smaller population than a United Europe would have. The gain in power of such a political reorganization might well be comparable to the advantage Europe gained long ago by being the first continent to go through the Industrial Revolution and the population explosion.

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ME8-0107

# Sensory Deprivation and Hallucinations

What conditions of minimal or controlled sensory stimulation favor the generation of hallucinations?

Jack Vernon, Theodore Marton, Ernest Peterson

In 1954, investigators working in the psychology laboratories of D. O. Hebb at McGill University began studies on how man responds to conditions of drastically reduced sensory input. Since then many other investigations have been made as a result of that work. Some workers have called the experimental situation isolation, some have called it reduction in variability of sensory stimulation, others term it perceptual isolation, and others (including ourselves) call it sensory deprivation.

Of the many important and interesting results of the original work at McGill none was more dramatic than the discovery that the isolation conditions elicited vivid and elaborate visual hallucinations. Twenty-five of the 29 subjects experienced some form of hallucinating activity; the time of initial occurrence of these experiences ranged from 20 minutes to 70 hours after the beginning of confinement.

Confinement in the McGill work was in a small, lighted cubicle, where each subject wore a pair of translucent goggles through which brightness, but not form, discriminations could be made. The masking noise of an air conditioner was also continually present during confinement. The subjects were asked to remain in confinement as long as they could, and this was usually 2 or 3 days. During the confinement the subjects could communicate at will with the experimenter through a two-way speaker system. Food was brought in upon request. The experimenter led the subject to an adjacent room to satisfy toilet needs. In all, these interruptions took up 2 or 3 hours per day.

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The Princeton series of experiments on sensory deprivation began about a year after the appearance of the first published report of the McGill investigations. The confinement conditions used at McGill were not duplicated, since we hoped to provide an extension of, and not a repetition of, those studies. In our work the subjects were isolated in a dark, lightproof, soundproof cubicle. The confinement cell was only slightly larger than the extra-long single bed it contained. A "panic button" was located inside the cubicle by which the subject could demand an early release if confinement became unbearable, and subjects were paid \$20 per day of confinement. Within limits, they did not know how long confinement was to last. We requested that they make themselves available for a block of 5 or 6 days; of this time we would use what was needed.

These were the general conditions of the sensory deprivation studies; variations of them or other special conditions, according to the particular study, are indicated below.

## First Study

The first group of subjects, only four in number, were confined under the mildest conditions of sensory deprivation we have ever used. They had their meals brought in to them on schedule, and they ate by the illumination of a 15-watt red bulb. Each subject was confined for 48 hours; during this time the subjects were blindfolded and led to the toilet upon request. Their confinement was twice interrupted in order to conduct learning tests.

Not one of these subjects reported any visual hallucinations. We reason that the opportunity for good vision with form discrimination at meal times may have prevented hallucinations.

## Second Study

In the second study the opportunity for sensory stimulation during confinement was reduced but not eliminated. Food was not brought into the cell but was stored there in advance of confinement. A food chest, stocked with sandwiches, soups, fruit, and water was available to the subject, and he ate *ad libitum* in total darkness. Toilet requirements were still a problem. Upon request, the subject was blindfolded and led down a long corridor to a toilet. There were usually about two such trips per day of confinement. We later learned that the blindfold was not entirely satisfactory and that minor light leaks occurred; at the time we considered this to be of little importance.

Of the 11 subjects confined under these conditions, nine completed 72 hours. Six of these nine subjects reported hallucinations. One subject experienced four different hallucinations, while the other five subjects reported experiencing two hallucinations apiece.

The reported hallucinations varied in content and complexity, and it was along these dimensions that we attempted to classify them. Type 1 hallucinations were defined as the simplest—those composed of flashing, flickering, and dim glowing lights which lacked shape or form and which appeared in the peripheral field of vision. Type 2 hallucinations were defined as having simple but definite shape, usually geometric in nature, and as occurring in the central visual field. Type 3 hallucinations were highly structured, integrated scenes containing many complex elements, movements, and so on, and more nearly resembled an ordinary visual experience.

Of the 14 hallucinations reported in this study, nine were of type 1 and five were of type 2; there were none of type 3. This finding is still somewhat in contrast to the results of most of the other investigations of sensory deprivation, where the reported hallucinations are of type 3 and of far greater frequency.

Of course, one of the major problems in this area is the adequate definition

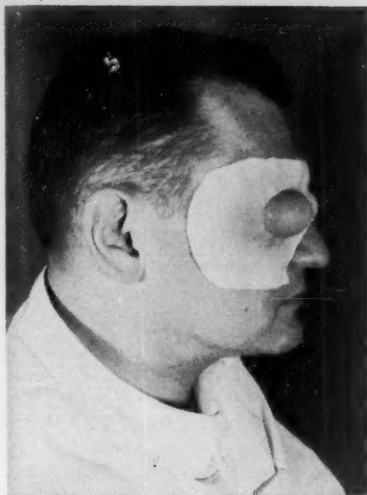


Fig. 1. Shaped ping-pong balls attached over a subject's eyes by mole skin.

of a hallucination as distinguished from vivid imagination, daydreams, hypnagogic visions, and so on. Our own attempt at a definition of hallucination led us to accept the following criteria: (i) it had to have an "out-thereness"; (ii) its content could not be controlled by the subject; (iii) its beginning or ending could not be controlled by the subject; (iv) it had to be scannable; and (v) ideally, it should "fool" the subject.

A consideration of the findings of the first two studies led us to believe that

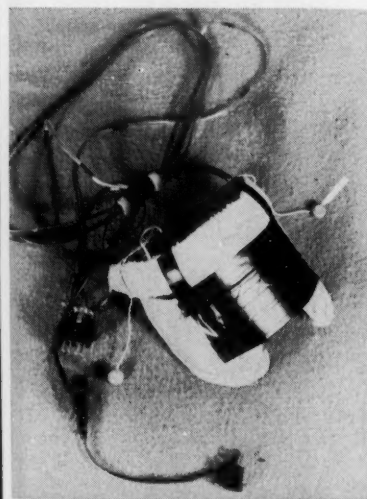


Fig. 2. Face mask devised to provide a constant level of illumination. The external insulation has been removed to show the construction of the mask. The arrow points to an ear phone.

the severity of the conditions of confinement was important for the generation of hallucinations. Thus it was decided to further reduce the opportunity for sensory stimulation in the next study.

### Third Study

In order that confinement should not be interrupted, and so that there would be complete social isolation, toilet facilities were provided within the soundproof chamber. These toilet facilities consisted of relief bottles placed within the confinement cubicle and a chemical toilet placed just outside it but still within the dark, soundproof chamber. These two facilities were sealable, so that odor was not a problem, and they could be easily used in total darkness.

With the addition of the new toilet facilities it was possible to confine subjects in total darkness without any chance of light leaks and without any human contact, as well as under soundproof conditions. Needless to say, in none of our studies were subjects allowed to make sounds such as talking, singing, and so on. A monitoring system revealed whether the subjects adhered to these instructions.

Under these conditions, nine subjects were confined for 4 days each. Only one hallucination, and a doubtful one at that, was reported. This particular report came toward the end of a confinement. The subject was about to eat a sandwich when he noticed that its edge "glowed." (Since it was a lunchmeat sandwich it is probably just as well that he threw it away!)

Our findings up to this point indicated that we had made the wrong assumptions as to which factors underlie the hallucinatory activity of sensory deprivation. For, within limits, it now appears that, contrary to our initial premise, as the sensory impoverishment of the confinement increases, the likelihood of hallucinations decreases.

As shown in preceding paragraphs, our second study yielded more reports of hallucinations than either of the other two; moreover, the second study was the one in which the accidental light leaks occurred around the blindfold which was used when the subject was taken to the toilet. Not only in our own studies did the presence of illumination seem important for hallucinations; it was also important in the



Fig. 3. Test subject wearing the face mask.

studies of others, such as the investigations at McGill, in which frequent hallucinations were reported. Therefore, we started another series of studies in which we utilized various kinds of visual stimulation.

### Fourth Study

We still felt that patterned illumination during sensory deprivation would inhibit the occurrence of hallucinations; otherwise, man in the everyday world might be plagued by them.

Instead of depending on accidental light leaks, with all their complications, we copied some of the McGill conditions. For example, we wanted a diffuse, homogeneous illumination which would not permit form discrimination. This we achieved by placing shaped ping-pong balls over the subjects' eyes, as indicated in Fig. 1. Illumination could be perceived through the celluloid hemispheres, but pattern vision was not possible. If the source of illumination had been fixed—say, in the ceiling of the cubicle—the intensity of the illumination would have varied as the subject's head moved. To eliminate this variability, the source of illumination was attached to a mask worn by the subject so that it moved with him and thus provided a constant level of illumination. Figures 2 and 3 show the arrangement of an illuminated panel attached to a welder's face mask which was fitted to the subject's head. The illuminated panel was made of Sylvania Fluorescent material which provided a





Fig. 4. A posed picture showing a subject's position in the cubicle and the arrangement of food and water (the subject would not wear a wrist watch in an actual study). The microphone hanging from the ceiling is for monitoring.

uniform, dull, pale blue-green glow that filled the entire visual field. The only way the intensity of the stimulus could be varied was by the subject's closing his eyes.

The arrangements for eating were also changed at this point; the cubicle was stocked with jars of junior-grade baby food, bars of tropical chocolate, and water. A jar of food could be opened as it was needed, and thus the possibility of spoilage and the need for refrigeration were eliminated. It was even possible for the subjects to control the selection of their food, despite the darkness, because the jars were coded. Each jar had a plastic spoon taped to it. If the jar contained a main course, the handle of the spoon was down; if it contained a dessert or a fruit, the handle was up, as indicated in Fig. 4. These foods were bland, nutritious, and completely adequate for confinement conditions. It should be pointed out, however, that almost all the subjects lost weight. In some cases the loss was as much as 5 pounds in 2 days of confinement. The mean loss in weight was just under 3 pounds; this, oddly enough, did not correlate with the amount of food consumed.

Ten subjects were confined under these conditions for 48 hours each. All were as thoroughly informed about hallucinations as was possible. They were briefed on the criteria of hallucinations as well as on the relevant characteristics which they should attempt to report. In addition, we emphasized that there was no stigma attached to having hallucinations under conditions of sensory deprivation.

Of these ten subjects, two experienced hallucinations—in all cases, of type 3. One subject saw a "skyline" and "a cogwheel turning slowly," while the other subject saw "a floral wallpaper design," "a river with floating white balls," "an archway," and "a chapel." Each of these hallucinations was very brief, lasting less than a few seconds.

The remaining eight subjects experienced no hallucinations.

#### Fifth Study

Results of the fourth study were neither clearly negative nor clearly positive with respect to the occurrence of hallucinations. This was the first time that type 3 hallucinations had been

reported in our studies, but, on the other hand, only two of the subjects experienced hallucinations at all. Our results up to this point clearly indicated that the conditions under which hallucinatory activity is maximum had not yet been found.

Another stimulus factor which was present in many other confinement studies in which frequent hallucinations were reported was monotonous sound. On the assumption that this added stimulation might in some way contribute to visual hallucinations, we next introduced sound along with the light stimulus.

As with the light, we attempted to present a sound stimulus which was constant. Thus, the sound was piped in to the subject through ear plugs of the hearing-aid type, which can be seen in Fig. 2. If the sound had been broadcast into the room from a fixed point, the subject would have been able to vary its intensity by moving his head. Our arrangement rendered the intensity of the sound stimulus constant, regardless of head position and movement. The sound stimulus used was thermal noise presented at 40 decibels above the subject's threshold for this kind of sound.



Eleven subjects were confined for 48 hours under these conditions of constant sound and light. None of them reported any visual hallucinations.

The tally of all our data up to this point is that, of 45 subjects, only nine experienced visual hallucinations. Clearly, then, we seemed to have made the wrong hypothesis regarding the conditions of sensory deprivation necessary for maximum occurrence of hallucinations.

Before turning to the next study, however, we want to report two interesting observations concerning the visual stimulus utilized in the fourth and fifth studies. All subjects reported that the light stimulus soon lost its blue-greenish color and became a dark gray, but oddly enough, the color was immediately restored with each blink of the eye. Once restored, however, it quickly seemed to fade again to a gray. Thus, the visual stimulus was not as constant as we had hoped it would be, and perhaps it is impossible to obtain complete constancy.

The second item of interest was the total absence of afterimages for all subjects. At the end of the confinement the illumination was extinguished and the subject was plunged into complete darkness. Normally, under these conditions, with a stimulus of this intensity and duration, afterimagery would have been very pronounced. However, such was not the case, although the subjects were specifically instructed to look for afterimages and did so for a considerable period of time.

### Sixth Study

As shown earlier, the greatest frequency of hallucinations in our investigations occurred during the second study. In that study accidental light leaks were present, due to faulty blindfolds which were utilized twice each day of confinement. At first we thought the important feature was that non-patterned vision occurred, but our findings now seemed to place importance upon the noncontinuous nature of the stimulus. Thus we decided to present a brief light stimulus which was amorphous, multicolored, and of low intensity. Obviously the rationale for some of these conditions was little better than hunch.

The visual stimulus was presented on a 30- by 30-inch panel on the wall at the foot of the subject's bed. The visual



Fig. 5. The headgear that holds the subject's microphone.

display was composed of smears and pieces of pastel-colored chalk, which became luminescent when illuminated by black light. When the panel was activated it appeared to have an amorphous tridimensionality which somewhat resembled a dark and distant starry sky. The starters for the black light were removed from the light fixture and placed outside the experimental chamber because they made a buzzing sound during operation.

The subject no longer wore the mask of the previous study but was equipped with the headgear shown in Fig. 5. A microphone was placed in front of his mouth so that he might report hallucinations at the time of their occurrence.

Ten subjects were confined for 48 hours, during which time the panel was illuminated for at least two 1-second periods every 8 hours. Such a schedule could not be followed rigidly because the subject was often asleep when scheduled to receive the stimulus; nevertheless, the schedule was followed as closely as possible. (It was possible to determine when the subject was asleep by listening to his breathing sounds.)

Of the ten subjects in the sixth study, only one reported visual hallucinations. This particular subject not only had every possible variety of hallucination, but he also had an unbelievably large number of them. He made a total of 96 reports, reporting 18 hallucinations of type 3, 11 of type 2, and 12 of type 1, and reporting on 45 other occasions that "the level of illumination in the room has changed" when he was actually in total darkness. The great frequency of his reports

seemed to be more an indication of a need to maintain contact with the outside world than a measure of hallucinatory activity.

In connection with the sixth study, several incidental findings are of interest. For one thing, almost all subjects in the sixth study had the strong impression that the visual panel was illuminated by a light from behind their heads. Actually, the source of illumination was immediately below the panel. These subjects did not assume that the illumination came from behind them but, as they reported, they seemed to "see" it as coming from behind them. We are at a loss to understand these reports.

The subjects did not know in advance that visual stimuli would be presented to them during confinement. At the first presentation a few subjects expressed doubt about the reality of their visual experience. With the continued presentation, they quickly became aware of the true nature of the stimulus. A subject usually verified his opinion by waving his hands before his face while the stimulus was on.

### Auditory Hallucinations

Up to this point no mention has been made of the occurrence of auditory hallucinations, and for good reason. If the identification of visual hallucinations offers some complications, the situation is even worse for auditory hallucinations. The problem is that one can never be sure that the sounds heard are not real sounds rather than hallucinatory ones. It is never possible to be absolutely sure that no sound has reached the ears. Even in entirely soundproof quarters, where there is no possibility of hearing any external sound, one can still be auditorially stimulated by one's own breathing noises, pulse sounds, middle-ear muscles, and so on. In our sensory deprivation cubicle, which afforded 80-decibel sound attenuation, it was still possible to detect certain faint building and construction noises. Thus, when a subject reported "hearing" something there was always some possibility that the sound was real and not hallucinatory.

Nevertheless, there were still some reports of auditory phenomena which were of interest. There were no occurrences of elaborate auditory hallucinations such as "voices" or "music," but many subjects reported hearing "soft rain" or "soft rain on a tin roof."

These reports could not have been produced by real rain sounds because of the soundproofing of the cubicle, and besides, often no rain had fallen.

Many subjects reported hearing "muffled engine noises," such as truck engines. It may be that they expected to hear highway noises, since there is a highway near the laboratory. In the same vein, several subjects reported hearing "the school bells"; this again may have been more an expectation than an actuality.

As explained earlier, in the fifth study sound was constantly present during confinement. That sound had no effect upon these reports of auditory phenomena. It did not produce unique auditory hallucinations, and it did not

terminate reports of the kind described above. We feel that the auditory phenomena were probably auditory illusions rather than hallucinations.

### Conclusions

At this point in our studies of sensory deprivation we can only conclude that we have yet to ascertain the maximum conditions for the generation of hallucinations. In all of the attempts we have made so far we have failed to obtain the frequency of reported visual hallucinations found in the investigations of others.

We subjected 55 subjects to various degrees of sensory deprivation and

found that only ten of them experienced visual hallucinations. These predominantly negative findings nevertheless lead to some positive statements about sensory deprivation and hallucinations. For example, it appears that absolutely maximum conditions of sensory deprivation do not elicit hallucinations. It also appears that neither continuous homogeneous nor momentary amorphous visual stimuli during sensory deprivation lead to hallucinations. However, because some hallucinations were reported in our studies, we may not assume that hallucinogenic factors were completely lacking. Our continuing program of research on sensory deprivation includes attempts to isolate these critical factors.

## Science in the News

### Space Communications: The Future Is Not Far Away, But the Major Policy Questions Are Unresolved

The Federal Communications Commission this week brought together a group of representatives of the communications industry and government agencies to begin exploring arrangements for development of an international satellite communications system. The direct issue, as put by John Finney in the *New York Times*, is "who shall sow and who shall reap the first big financial dividends of the space age . . . who shall own and operate a communications satellite system that would open up vast new channels of communications between all the nations of the world."

The FCC does not have the authority to give the definitive answers to these questions. They raise the question of the extent of government participation in the system that may be desirable or necessary, and at least the possibility of outright government ownership. The FCC must work under the

assumption that the system will be privately owned. Any departure from this assumption would have to be made by the White House and Congress.

What the FCC tried to do this week was to make a start toward settling the conflicts among the segments of private industry and to lay the basis for industry representatives to get together and work up a proposal showing what industry feels it can accomplish.

The American Telephone and Telegraph Company has already asked for permission to go ahead with a plan for putting 20 satellites in orbit in order to have a commercial system for transatlantic communication in operation by 1964. A.T.&T. would pay for the satellites and the cost of putting them in orbit. But the Antitrust Division of the Justice Department has come out against any single company's dominating satellite communications, and the assumption behind the meeting this week was that a consortium of corporations in the international communications field should jointly manage any proposed system. But it is far from

settled whether this will be the actual approach decided upon, and if it is, it is only an approach, providing only the framework for the answers, not the answers themselves, to the very complicated problems of how the system should be financed, controlled, and operated, and who should profit from it.

### Time Factor

The great significance of the A.T.&T. proposal, with its operating target date of 1964, is the forceful reminder it offers of how quickly difficult decisions must be made if the United States is to take full advantage of the lead it holds over the Russians in the practical uses of space. This was again emphasized in Kennedy's inclusion, in his expanded space budget, of \$50 million extra for fiscal 1962 to speed the development of communication satellites. This more than doubled the \$44 million already requested, and a good part of this speeded-up spending is pointless unless we intend to make prompt use of the satellites once they are developed.

None of the development money would be spent specifically to set up an operating system, but the prototype satellites put up will be usable. The first of the Project Relay satellites, which will receive, amplify, and re-broadcast signals, is scheduled for mid-1962. It will travel in an elliptical orbit ranging from 1000 to 3000 miles above the earth, and will be in sight of stations on both shores of the Atlantic Ocean for 10 to 35 minutes out of an orbiting time of 180 minutes. Conditions will be right for transatlan-

tic communication for three or four consecutive orbits per day.

During these periods it will be possible to transmit live telecasts across the Atlantic. Also, with techniques already available, by using high-speed transmission, the 10- to 35-minute transmission periods may be more than sufficient to transmit a television program that will last several hours when rebroadcast at normal speed, perhaps long enough to cover the 3-hour period until the satellite swings around the world and is in position for another burst of transmission. This does not quite make possible extensive live transatlantic television, since the system, with only one satellite available, will under these circumstances involve several hours' lapse between an actual event and the time it is seen on television screens across the ocean. But either the brief "real time" transmissions or the high-speed transmissions would be a great advance in transatlantic television coverage. The closest thing now available is for the TV networks to charter a plane to fly TV film across the Atlantic. This first step toward an operating satellite system has plain enough commercial value to make only a year away, if the schedule is met, the problem of how the use of this facility is to be allocated, and how much should be charged for its use.

#### Touchy Questions

The problems involved in this situation are trivial compared with those that will come later, but once again they are a reminder of how soon definite decisions have to be made and policies have to be decided on.

The basic policies and decisions may be extremely controversial. Immense amounts of public money have made these satellites possible, and the national interest is deeply involved in their early development into actual operating systems. The costs of putting up the first full system have been estimated at around \$400 million, and industry estimates have suggested this "business" of world-wide satellite communication will involve tens of billions a year within 15 years.

What kind of voice, if any, should the United Nations or some other international body have in the arrangements under which the system is used and over the rates that are charged? How much should the government attempt to recapture its "investment" in developing these satellites from the

commercial revenues that will result? Does private industry have the capital to develop these systems as quickly as may seem desirable? If not, under what arrangements should the government supply the additional capital needed if the systems are to be privately owned? Should there, indeed, be private ownership, or should the government create and own the system and merely rent access to it to commercial communications companies, as the telephone company rents access to its communication lines?

The last is the central problem. The Eisenhower Administration, in its final days, laid down the policy that "the government should aggressively encourage private enterprise in the establishment and operation of satellite relays for revenue producing purposes." This private enterprise, of course, would be under government regulation, as are all public utilities. The Kennedy Administration has said nothing, one way or the other, about this policy, and so, by implication, it still stands. The FCC invitation to the private communications companies to send representatives to Washington this week followed a preliminary decision by the FCC 3 weeks ago that the first system might be put up by a consortium of private corporations in the field. But that decision was intended to settle the ground rules for private participation rather than to decide the question of public versus private ownership.

The decision indicated that the FCC shares the Justice Department view that no one company should dominate the venture, and it defined the types of companies eligible for participation in the consortium and the rights of other companies with interests in the field, but which might not be members of the consortium. Essentially, it was merely a necessary first step for making the more basic decision over public versus private ownership, since in order to compare the relative merits of the two approaches an arrangement had to be made for industry to present its proposals for developing the new area.

#### Ownership

The new Administration does not share Eisenhower's strong distaste for new federal activity, and there is strong feeling in the Democratic party that, as a matter of principle, an effort involving as much public money and as deep a national interest as this does not only could, but should, be publicly

owned. If the decision is for private ownership there will be vigorous cries of "giveaway," and if the decision is for public ownership, there will be even more vigorous cries of "socialism."

The central question is whether the national interest in the speed with which the systems are developed and in the way they are operated can be as well served by government-regulated private ownership as by public ownership.

This involves not merely such obvious questions of whether industry has the capital to put up a system as quickly as seems desirable, but as FCC Chairman Minow warned the industry representatives this week, of whether the system meets not only the commercial interests of the participating companies but the national interest in a system that would be world-wide, rather than confined mainly to the more profitable high-traffic areas, principally between North America and Western Europe, and a system which makes participation available to all interested nations, small and large, around the globe. "Any plan," Minow said, "not in the public interest in any respect will not be approved." Any attempt to define the public interest opens a wide area of controversy centering around the extent to which the Administration's view of foreign-policy requirements conflicts with the type of system that would seem best on purely commercial grounds.

Given the Eisenhower Administration's feelings about the evils of public ownership and its desire to keep down the size of the federal budget, its decision in favor of private ownership was almost foreordained. It naturally resolved any doubts in favor of private ownership. The Kennedy Administration has no really strong commitment either way, although if the decision seemed close, it too would resolve its doubts in favor of private ownership, if only because although either decision would be controversial, the decision in favor of private industry would be much less so. On the other hand, with the new Administration there is a real possibility that the Eisenhower policy will be reversed. If so, the Administration may choose to avoid saying anything in public until Congress has finished its current session, lest the controversy hurt the chances of other parts of the Administration program. But any decision involving government participation must eventually



be brought before Congress, since nothing can be done unless Congress is willing to authorize and then appropriate the money to go ahead.

What makes a controversy of some sort inevitable either way is that the problem is more than complicated enough so that it will be easy to make a case in favor of either approach, and nearly everyone will have no trouble convincing himself that the view he would tend to favor in the lack of any evidence is, by some happy coincidence, precisely the view supported by a careful study of the arguments on both sides.

### The Test Ban

The Vienna talks were a "success" within the terms set by the Administration at the outset. No false hopes were raised, and the meetings ended with no illusions of accommodation. The meetings gave Kennedy a chance to size up Khrushchev in person, and vice-versa; Kennedy had apparently made a strong impression on the Europeans; and these limited accomplishments were enough to satisfy most observers that the episode had been, as Administration spokesmen described it, "useful."

The meetings, nevertheless, left the Administration with the problem of how to deal with the test-ban talks, and with no longer much hope that the Russians are going to make the decisions any easier. Khrushchev confirmed the Russian interest in merging the talks with the general disarmament discussions to begin later this year, and, according to reports, he vigorously defended the new Soviet doctrine of three-headed control bodies for international agencies, including those to police disarmament, with the Soviet, Western, and neutral blocks each having a veto. To the West, this is like a court in which either of the opposing attorneys can veto the judge's decisions. For the moment, the Administration's negotiators at Geneva continue to press on day after day, even though there no longer seems much to negotiate about, in order to impress on the world our willingness to reach an agreement, if it is at all possible. At home, the United States Information Agency, under Edward R. Murrow, and other agencies are working on the problem of how to minimize the adverse world reaction that seems inevitable should it become necessary, after all, to resume nuclear testing.—H.M.

## Announcements

A vehicle designed to do the work of a diver on the ocean floor is undergoing performance trials at the Scripps Institution of Oceanography, La Jolla, Calif., where it was designed. The machine, called a **remote control underwater manipulator**, or RUM vehicle, has a hand-like manipulator which is controlled from shore through a coaxial cable carrying, simultaneously, 38 sets of commands to the machine and two television signals from it.

The vehicle is driven by an electric motor and is able to withstand water pressures of 10,000 pounds per square inch. Two of its television cameras scan the ocean ahead, one searches behind, and the fourth follows the movements of the manipulator. When ready for operation, the vehicle will be used in various oceanographic research projects.

Britain and Russia have signed a 5-year agreement for collaboration on the **peaceful uses of atomic energy**. The first of a series of exchange visits will take place before the end of the year. The agreement was signed by V. S. Emelyanov, chairman of the State Committee for Atomic Energy of the Soviet Council of Ministers, and Sir Roger Makins, chairman of the United Kingdom Atomic Energy Authority.

A new scientific association, the **International Union of Geological Sciences**, was recently formed after a meeting of geologists from 25 countries held at UNESCO House, Paris. The union, now a member of the International Council of Scientific Unions, was formed on the basis of a proposal adopted at the 1960 meeting of the International Geological Congress. J. M. Harrison, head of the Geological Survey, Ottawa, Canada, has been elected president; vice presidents are I. I. Gorski (U.S.S.R.), L. Hawkes (United Kingdom), Teichi Kobayashi (Japan), Lamego (Brazil), Jean Lombard (France), and B. C. Roy (India).

A new **information and analysis center**, to evaluate reports and publications containing seismic information on explosions and earthquakes, has been established by the University of Michigan's Institute of Science and Technology. Supported by a contract from the Advanced Research Projects

Agency (ARPA), the institute's Fluid and Solid Mechanics Laboratory is setting up the VELA Seismic Information Analysis Center (VESIAC). The center will evaluate and disseminate information gathered in the seismic research portion of the ARPA Vela-Uniform program, the national program of research in the detection and identification of underground nuclear tests. It will also be responsible for summarizing current seismic knowledge which may be useful to the program.

### Grants, Fellowships, and Awards

**Fulbright scholarships** for graduate study or predoctoral research in 32 countries will be available to over 800 graduate students for the 1962-63 academic year. In addition, awards for graduate study in Latin America and Ireland will be offered. Requests for application forms must be postmarked not later than *1 October 1961*; applications will be accepted until 1 November. (Information and Counseling Division, Institute of International Education, 1 E. 67th St., New York 21)

Modest grants to assist individuals wishing to study at the Chicago Natural History Museum are available for work in any of the following fields: **anthropology** (with a natural-history orientation), **botany** and **geology** (including paleontology), and **zoology**. An applicant should briefly describe the proposed study, state how long he would like to study at the museum and the amount of money needed, and name one reference. (Chairman, Karl P. Schmidt Fund, c/o Chicago Natural History Museum, Roosevelt Rd. and Lake Shore Dr., Chicago 5)

The National Science Foundation is accepting applications for fellowships under its **postdoctoral fellowship program through 5 September**. The awards consist of a stipend of \$5000 per year, dependency allowances, and limited travel allowances. Eligibility requirements include U.S. citizenship, special aptitude for advanced training, and a doctoral degree or its equivalent in education and experience. Fellows will be selected on the basis of ability as evidenced by letters of recommendation and other evidence of scientific attainment. (Fellowship Office, National Academy of Sciences-National Research Council, 2101 Constitution Ave., NW, Washington 25, D.C.)



## Meeting Notes

An international symposium on **aerospace nuclear propulsion**, sponsored jointly by the Atomic Energy Commission, the Institute of Radio Engineers' Professional Group on Nuclear Science, and the National Aeronautics and Space Administration, will be held 24-26 October. Tentative topics include advanced propulsion systems, engine characteristics and dynamics, recent advances in nucleonic instrumentation, engine simulation and control, effects of nuclear radiation on controls and instruments, and non-nuclear and nuclear instrumentation for aerospace propulsion. Rough drafts and 500-word abstracts of papers to be presented should be submitted by 1 July. (P. M. Uthe, Lawrence Radiation Laboratory, Livermore, Calif.)

A workshop on **dynamic programming**, sponsored by the Nonlinear Control Subcommittee of the American Institute of Electrical Engineers, will be held at the University of Colorado on 27 June. The basic theory of dynamic programming will be presented in addition to its present applications, sample problems, and directions of new study. (Richard Kuba, Power Equipment Co., P.O. Box 3556, Beechwood Station, Columbus 14, Ohio)

## Scientists in the News

**Irving Klotz**, biochemist at Northwestern University, has won the American Chemical Society's Eli Lilly award for his studies of proteins.

**Alan Johnson**, assistant professor in the department of medicine at New York University Medical Center, has been appointed director of a new research laboratory to be established at Bellevue Hospital by the American National Red Cross. Johnson will supervise investigation on the dissolution of blood clots similar to those responsible for coronary thrombosis, phlebitis, and strokes.

**John F. Flagg**, manager of the materials engineering laboratory, General Electric Company, Schenectady, N.Y., has been appointed director of research for American Cyanamid Company's Central Research Division. Prior to joining GE in 1946, Flagg was assistant professor of chemistry at the University of Rochester.

**Richard L. Dobson**, assistant professor and head of the dermatology division at North Carolina School of Medicine, has been appointed associate professor of dermatology at the University of Oregon Medical School. Also appointed to a new position at the school was **Robert E. Swanson**, assistant professor of physiology at the University of Minnesota Medical School, who will become associate professor of physiology.

**E. B. Brown, Jr.**, professor of physiology at the University of Minnesota, will become professor and head of the department of physiology at the University of Kansas Medical School on 1 July.

**Jackson W. Foster**, professor of microbiology at the University of Texas, has been named by the U.S. Office of Naval Research to undertake a special study of the status of microbiological science in Europe and the Middle East. He will be assigned to the U.S. Embassy in London as scientific officer for approximately 1 year, beginning 1 September.

**George H. Morrison**, head of inorganic and analytical chemistry at General Telephone & Electronics Laboratories, Bayside, N.Y., has been appointed professor of chemistry at Cornell University, effective in July. He will also head the analytical program of the university's Materials Science Center.

**James A. Halsted**, who formerly held the posts of assistant to the vice president, associate professor of medicine, and director of postgraduate medical education at the University of Kentucky Medical Center, has been appointed chief of the department of medicine at the Metropolitan Hospital and Clinics, Detroit, Mich.

**William M. Brown**, associate professor of electrical engineering at the University of Michigan, has been appointed head of the radar laboratory at the university's Institute of Science and Technology. He succeeds **L. J. Cutrona**, who resigned in order to devote more time to teaching.

**William E. Koch, Jr.**, professor of clinical radiodontics at the Washington University School of Dentistry, has been appointed professor of oral diagnosis and radiology at the university.

**Theodore Lidz**, professor of psychiatry at Yale University School of Medicine, is the first recipient of the Frieda Fromm-Reichman award for research in schizophrenia, presented 6 May at the Chicago meeting of the American Academy of Psychoanalysis.

**James M. Ham**, professor of electrical engineering at the University of Toronto, is currently visiting the U.S.S.R. Academy of Sciences under the official exchange agreement between the academy and the National Research Council of Canada.

**Harry S. Gear**, director of pneumoconiosis research for the Council for Scientific and Industrial Research-Industrial Medicine in Johannesburg, South Africa, will become secretary general of the World Medical Association on 1 July.

## Recent Deaths

**Harry A. Bright**, 71; metallurgist; was chief of the National Bureau of Standards' analytical chemistry section from 1936 to 1960; 22 May.

**Lindsay P. Disney**, 65; tides expert and assistant chief of the U.S. Coast and Geodetic Survey's marine data division; 23 May.

**Manfred Engel**, 31; radiation bacteriologist in Oak Ridge National Laboratory's Biology Division since 1958; 1 May.

**George I. Finlay**, 85; professor emeritus of geology at New York University; 5 May.

**Arnold L. Gesell**, 80; child psychologist and former research consultant for the Gesell Institute of Child Development; previously professor of child hygiene at Yale University School of Medicine; 29 May.

**Ivor Griffith**, 70; president of the Philadelphia College of Pharmacy and Science since 1941; 16 May.

**E. Lee Kinsey**, 57; professor of physics and former chairman of the department at the University of California, Los Angeles; 27 May.

**Cleon Nafe**, 69; surgeon and associate professor of surgery at Indiana University Medical School; 29 Apr.

**Harry P. Newton**, 65; chemist at the U.S. Department of Agriculture from 1927 until his retirement in 1956; 21 May.

**Louis M. Orr**, 61; urologist and president of the American Medical Association in 1959-60; 22 May.

## Book Reviews

**Pul Eliya, A Village in Ceylon: A Study of Land Tenure and Kinship.** E. R. Leach. Cambridge University Press, New York, 1961. 360 pp. Illus. \$8.

Pul Eliya is a Sinhalese village with 146 inhabitants in the dry zone of North Central Province, Ceylon. With a wealth of concrete, illustrative material, Leach analyzes and describes the physical structure of the village, its family and kinship organization, its land tenure system (both traditional and nontraditional), and its organization of labor. Besides making an important contribution to the anthropology of Ceylon, he has produced a book notable for other reasons.

Some critics of anthropology object to intensive studies of little communities such as Pul Eliya, for they consider the studies devoid of practical value. Why try to learn all that detail about an obscure village? What we need are broad surveys which enable us to get the "big picture." There is a place, of course, for surveys. They determine the extent to which it is safe to generalize conclusions from studies like this one, and they provide a check on interpretations of functional relationships in the single case. Work in other Sinhalese villages will undoubtedly require some modification of Leach's understanding of what he observed in Pul Eliya. But no survey is worth anything unless intensive studies have been made first. In spite of all their trappings of quantitative rigor, surveys give precise answers only to the questions which investigators know to ask. Without the intensive studies to tell them what to ask, the information obtained from surveys has little to do with reality, no matter how carefully such information is collected. Thus Leach finds that most land legislation in Ceylon has been based on entirely erroneous conceptions of how the tenure systems in the villages actually work, misconceptions which previous surveys in no way dispelled. His explication of how land tenure works in Pul Eliya,

in practice as well as in theory, and his account of the effects of misinformed government legislation effectively demonstrate the practical as well as the scientific value of intensive studies of single communities. *Pul Eliya* should be on the required reading list of all legislators and administrators who are concerned with the welfare of peasant communities.

### Challenge to Radcliffe-Brown School

Of special interest to anthropologists is the challenge Leach offers to his fellow social anthropologists of the British or Radcliffe-Brown school. In Pul Eliya Leach found it impossible to work within their theoretical frame regarding corporate groups. He concludes that a social structure, in the prevailing social-anthropological sense of that term, "must necessarily be credited with the attributes of Deity. The anthropologist with his wealth of detailed knowledge of the behavioural facts claims an intuitive understanding of the jural system which holds these behaviours in control. When he writes his structural analysis, it is this private intuition which he describes rather than the empirical facts of the case. The logical procedures involved are precisely those of a theologian who purports to be able to delineate the attributes of God by resorting to the argument from design.

"Of course, it is all very elegant, but it is not a demonstration; the structuralist anthropologist, like the theologian, will only persuade those who already wish to believe" (pages 301-2).

Insofar as the structure of a community is an abstraction from the modalities of event and arrangement which characterize it as a relatively stable system, and insofar as this abstraction is then treated as a system of rules governing the conduct of its members, Leach is entirely right. That one of Britain's leading social anthropologists has come to this position is of great importance for the future of social anthropology.

But Leach's conclusion—"the group itself need have no rules; it may be simply a collection of individuals who derive their livelihood from a piece of territory laid out in a particular way" (page 300)—is one which he has not demonstrated, even for Pul Eliya, unless we assume that "rules" can refer only to the kind of abstraction which Leach rightly argues cannot be treated as if it were a rule of the society. But the recurring patterns of arrangements in a community from which rules are improperly abstracted, in the manner Leach deplors, may legitimately be viewed as the products of human decisions which are themselves made with reference to the mutual understandings that make events, both common and rare, intelligible to their participants. Leach has rightly thrown out the rules of the sociological structuralist, but if, as he says, "society is not a 'thing'" but "a way of ordering experience" (pages 304-5), then implicit in that ordering are principles or rules analogous to the phonological, morphological, and syntactic principles characterizing a language and without which speech could not be an orderly process. Although rules in this sense are also formulations of the anthropologist, their validity for the society for which they are specifically formulated can be tested against actual events in that society. Efforts to develop more sophisticated inductive procedures for formulating such rules are a legitimate and essential scientific endeavor.

Leach has taken a major step in developing his own theoretical orientation. It will have wide repercussions among those who call themselves, by preference, "social" anthropologists.

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**World Prehistory.** An outline. Graham Clark. Cambridge University Press, New York, 1961. xv + 284 pp. Illus. Paper, \$2.45; cloth \$6.

In this volume Graham Clark, one of the leading specialists in the prehistory of Europe and Disney professor of archaeology at the University of Cambridge, has undertaken a formidable task and has carried it off quite well. His aim is "to present a brief outline of man's prehistoric past, . . . to survey in barest outline the history of mankind from the first dawn of

culture down to the time when successive societies attained literacy."

This is an ambitious design that quite naturally, in a work of 284 pages, calls for a great deal of compression. Although Clark bases his discussion almost entirely on concrete but fragmentary evidence, he found it impracticable to incorporate or even summarize the nature of the evidence itself. What he has done is to present a reasonably coherent picture of human cultural history from the earliest appearance of man as a tool-making animal to the emergence of adequately written history in different parts of the world at different times.

In a disarming paragraph Clark signals his awareness that "the varying intensity of archaeological research in different parts of the world, the author's unequal reading, and the insistent progress of knowledge, which modifies conclusions almost before they can be set down, all help to distort the picture."

Paradoxically, although the author specifically eschews an attempt at artificial evenness of treatment, the actual structure of the book, by virtue of its relatively even chapter lengths, superficially approximates just that, and results in a certain lack of balance.

The first chapter, entitled "Man's place in nature," is fairly evenly divided between physical environment and biological evolution. The next two chapters, which span 50 pages, discuss Lower Paleolithic cultures and their survivals, on the one hand, and advanced Paleolithic and Mesolithic cultures on the other. Here Clark is dealing with his own specialties and is at his best. "The invention of farming and the rise of Mesopotamian civilization" occupies 23 pages, and "Ancient Egypt and the later prehistory of Africa" only 20 pages. By contrast, "Neolithic peasants and arctic hunter fishers" in Europe runs to 28 pages, and "From Mycenae to the age of expansion" runs to 33 pages. Since both of these chapters are subdivisions of a broader topic, the foundations of European civilization, this disproportionate bias is understandable, particularly since our archeological evidence for much of Continental Europe and the Mediterranean is fairly complete and therefore quite confusing.

On the other hand, to treat India and the Far East, including China, Southeast Asia, Indonesia, and the Philippines, as well as Japan and Northeast Asia, in 32 pages, the New

World, encompassing North America, Mesoamerica, and South America, in 28 pages, and Australia and the Pacific in 11 pages is likely to cause the professionals who specialize in those areas to gasp.

It is obvious that Clark could do no more than present his own interpretations and that only occasionally could he outline some area of disagreement, and it is also obvious that he had to omit much relevant material. This, then, is the kind of book about which the expert can and does say, "This is excellent, stimulating and informative, but for my area. . ."

It is not a book to read at one sitting, for the compression of material has resulted in a density of style. Each chapter must serve as a point of departure for further reading or lectures to fill in the gaps, repair omissions, and assess conflicting interpretations. But as an introductory text that leads the reader into unfamiliar territory this book deserves a place on the reference shelf of the professional archeologist, the serious student, and the interested layman.

ROBERT W. EHRICH

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**Science Since Babylon.** Derek J. de Solla Price. Yale University Press, New Haven, Conn., 1961. 149 pp. \$4.50.

The author delivered five of the six chapters of this book as public lectures in a prolegomenon to a program in the history of science and medicine at Yale. He wisely concentrated attention on certain "crises," in the study of which he has himself made valuable and important discoveries or suggestions. His enthusiasm is infectious and will convey in print, as it must surely have done by the spoken word, the variety of opportunities that await the scholar in this, the newest field of historiography.

Price tells of the complements of Greek geometrical model and Babylonian computation in Ptolemy's *Almagest*. The comparisons of clockwork between China and the West is a well-told detective story, containing clues for a fuller tale of cultural relations. A chapter on the technological background of American science takes a more generous view than has been fashionable of our national heritage in

this field. An essay on discovery in radiation grapples with the problem of what to do with recent history in science. There is a most suggestive study of the quantitative growth of science. The book closes with an appeal for institutionalization of what the author calls "humanities of science," of which the reader is to take the five substantive chapters as samples. I find this summons a little apocalyptic and would prefer to refuse the choice of all or nothing. And perhaps one need not make it in order to enjoy and profit from the excellent observations and curious facts that abound in a brief, delightful, and intriguing book.

CHARLES COULSTON GILLISPIE

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**Anatomy of Monocotyledons.** vol. 1, *Gramineae*. Charles Russell Metcalfe. Oxford University Press, New York, 1960. lxi + 731 pp. Illus. \$13.45.

A more appropriate title for this excellent reference work would have been "Leaf Anatomy of the Gramineae." Leaf anatomy is emphasized because "in the vegetative organs of the Gramineae the most important characters are to be found in the leaf." The volume is the culmination of over 10 years of research by Metcalfe, and it records the data for 206 genera and 413 species examined. In addition, the literature has been summarized and blended with the author's results, so that 345 genera have been treated.

There are chapters on the general morphology of the grass plant, on the diagnostic microscopical characters, and on the leaf structure and taxonomy of grasses, but the major part of the book records the details of leaf anatomy. The genera are arranged alphabetically under each of two divisions: the genera not in the Bambuseae and genera in the Bambuseae. The diagnostic characters of each genus are followed by the detailed anatomy of selected species. This usually includes only the abaxial epidermis of the leaf and a transverse section of the lamina, but sometimes the anatomy of the culm and other parts are given. The source of the material examined is indicated for each species. Sometimes it is from plants cultivated at Kew and sometimes from a specific herbarium specimen. Additional information from the literature is considered separately.



Special features of the book include lists of genera and species in which certain diagnostic characters occur (40 pages), an extensive bibliography (20 pages), and 29 plates of fine drawings which illustrate the anatomical characters.

There is little said of phylogeny for "We . . . recognize that the grasses appear to represent an advanced group of monocotyledons, but . . . we can say little or nothing about lines of phylogenetic advance within the family." "It seems as if it will be more profitable, at this stage, to concentrate on discovering natural taxonomic groups rather than to speculate concerning the phylogeny of the grass genera as we know them today."

The book is indispensable to agronomists whose research interests are in taxonomy or related fields.

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**Humid Tropics Research. Problems of Humid Tropical Regions.** 102 pp. Illus. \$3. *Study of Tropical Vegetation.* Proceedings of the Kandy Symposium, jointly organized by the Government of Ceylon and UNESCO. 266 pp. \$6. UNESCO, Paris, 1958.

These bilingual volumes, published by UNESCO on the occasion of the preparatory meeting of the International Advisory Commission on Humid Tropics Research, are the first publications of the Humid Tropics Research Program. F. R. Fosberg (U.S. Geological Survey) attended this meeting and is now the member for the United States.

*Problems of Humid Tropical Regions* is a collection of six reports commissioned at the eighth session of UNESCO as the first part of a program "to promote the co-ordination of research on scientific problems relating *inter alia* to the humid tropical zone and to promote international or regional measures to expand such research."

There are three general reports. One by Felisberto C. Camargo (Servico Nacional de Pesquisas Agronomicas, Rio de Janeiro) deals especially with his siltation techniques that increase the amount of flood-plain lands. These flood plains are of high agricultural value, in contrast to the relatively

sterile "high ground." A second paper is by Enrique Beltran (Instituto Mexicano de Recursos Naturales Renovables, Mexico) and is concerned with the Caribbean region. Beltran's report surveys the natural resources of the lands about the Caribbean Sea and includes a 297-title bibliography. In the third paper, E. K. Janaki Ammal (Central Botanical Laboratory, Botanical Survey of India) reports on Burma, Ceylon, India, and Pakistan.

There are three special reports. One, by G. Marlier (then of the Institut pour la recherche scientifique en Afrique centrale in the former Belgian Congo) is on biological problems of tropical humid Africa. A second, by A. P. Kapur (Zoological Survey of India, Calcutta), is on entomological problems in South Asia, with separate discussions on major crop plants, forests, stored products, and human health, and with a 376-title bibliography. The third is on the Philippines and the state of its water resources development, with considerable discussion of the interlocking problems of agriculture, fisheries, soil erosion, and forestry.

Both the general and the special reports in this volume are valuable contributions to regional geography, with varied emphasis on special problems.

For those interested in world vegetation, *Study of Tropical Vegetation* takes its place on the same shelf with Rübél's *Pflanzengesellschaften der Erde* and Richard's *Tropical Rain Forest*. *Study of Tropical Vegetation* is based on the Kandy Symposium, which was sponsored jointly by Ceylon and UNESCO, and is comprised of 26 papers; each paper is a summary and evaluation of existing vegetation knowledge, includes a valuable bibliography, and points to the needs for further research. The following areas are covered: India and Burma (Puri); Indonesia (Dilmy and Kostermans); Ceylon (de Rosayro); Malaya (Wyatt-Smith); British Guiana and Nigeria (Richards); the Philippines (Bedard); the islands of Oceania (Fosberg); eastern India (Chatterjee); Malaysia (van Steenis); Madhya Pradesh and the Gangetic Valley of India (Misra); Singapore (Purseglove); India (Bharucha); Ceylon (MacFadden, who emphasizes aerial techniques); Ceylon (Holmes, who stresses the role of the old civilization in determining the present dry evergreen forest); Ivory Coast (Mangenot); Papua and Northwest New Guinea (Taylor and Stewart, who apply the excellent techniques developed by the

commonwealth Scientific and Industrial Research Organization of Australia for regional resources surveys); India (Janaki Ammal); Pakistan (Hedayetullah); Borneo (Kostermans); Sarawak (Browne); British North Borneo (Wood); Australia (Webb); Ceylon grasslands (Senaratna); Viêt-Nam (Schmid); and Sarawak and Brunei (Anderson). Basic principles of rain forest sociology are discussed by van Steenis.

There follows a series of five special papers and discussions—ecological factors (Mangenot); vegetation types (Bharucha); the climax (Richards); reproduction in forest openings (van Steenis); and mapping (Fosberg). The volume includes generalized vegetation maps for Ceylon, the Ivory Coast, Pakistan, India, and Burma. It closes with 14 recommendations concerning national and international activities in this field.

*Study of Tropical Vegetation* is a milestone towards the coordination of vegetation thought and research on an international plane, even though it shows the urgent need for further co-ordination and for the eventual development of a mature international science. The nonpartisan reader will be impressed with the very considerable attention given in the papers and recorded discussions to the relative merits of "Clementsianism" (probably derived from the Weaver and Clements text, now rarely used in America) and the SIGMA (Station Internationale de Géobotanique Méditerranéenne et Alpine) school (which originated in southern France), with the former developing into hearty subarguments on the pros and cons of monoclimal and polyclimax theory. One senses that these workers are groping for a school, a philosophy, a methodology, and that all they have to choose from are the American and West European traditions, both of which have their limitations in the tropics. (But no less so than in temperate regions!) I sometimes wonder—I strongly suspect—that the odd theories and philosophies of these two schools are actually unconsidered by these workers. What appeals in the SIGMA school is the small-scale quadrat method (which, after all, is not its unique feature) and what appeals in Clementsian thought are the large regional units (which, again, are not unique to that group). And the two approaches are by no means incompatible. Rather, on these grounds, they are complementary. While read-



ing this volume, I often wished there was less reverence and veneration for what the West has contributed in the way of rigid schools of thought, and greater respect, by these workers, for their own individual abilities. These abilities might well be directed towards an international non-school-astic science, revolving around empirical descriptions, relative change, relative stability, and the influences of past civilizations and primitive man. In turn, Western thought in this field could not help but benefit.

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**Oceanography.** Invited lectures presented at the International Oceanographic Congress. AAAS Publication No. 67. Mary Sears, Ed. American Association for the Advancement of Science, Washington, D.C.; 1961. xi + 654 pp. Illus. Cash price to members, \$12.50; others, \$14.75.

Nearly 1200 marine scientists from two thirds of the nations of the world met for 2 weeks (31 August to 12 September 1959) in the United Nations Building in New York. A selected few of these scientists presented the essence of their life's work to this learned audience in invited lectures. For each topic, part of the audience was competent and critical and the remainder was academically interested but not familiar with the detail or the background. The committee is to be congratulated on their selection of speakers. To a man, they proved themselves scholars, masters of their subjects, and excellent raconteurs. All this is reflected in the book.

*Oceanography* includes sections on the history of the oceans, populations of the sea, the deep sea, boundaries of the sea, and cycles of organic and inorganic substances in the oceans. Each section contains four to seven articles, each dealing with some aspect of physics, chemistry, or biology or their interrelations in the sea, the sea bottom, or the sea surface.

I am struck by the similarity of organization achieved - between this volume and the *Discourses of Machiavelli*. In both, the authors explore factual situations, separate the local and fortuitous from the rules of general behavior, and point out successful and unsuccessful techniques. From

this background they define their goals and the possible approaches.

The book is a "sampler." It gives examples of successful marine research involving all academic disciplines. I doubt if even an avowed oceanographer will find every article to be of personal interest. On the other hand, any scientist, marine or otherwise, and in any field, will find one or more of the papers absorbing.

It is an outstanding reference book, at both the research and student levels. Each article includes the background, observation, reasoning, and conclusions to date on the topic. For the researcher the articles provide a most useful summary and a ready entry into the supporting scientific literature. Also, the discussions are mercifully condensed, clear, logical and readable. Much of the material can and should be used by university undergraduates, and even by high school students, as bases for term theses. In any case, the book should be required reading in science courses at the senior undergraduate level. Familiarity with living science, and with the research methods of the masters, is a part of education.

It is a book for the young scientist. I know of no other volume that so well defines oceanography, its purpose, opportunities, and requirements. Revelle, in his introduction, makes the point that oceanography is a field of research in which all disciplines of learning are combined. The volume demonstrates this by examples. It is evident that there is ample challenge in marine research for any good scientist.

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## New Books

### Biological and Medical Sciences

**Advances in Carbohydrate Chemistry.** vol. 15. Melville L. Wolfrom, Ed. Academic Press, New York, 1960. 457 pp. Illus. \$14.

**Anatomy and Physiology.** Diana Clifford Kimber, Carolyn E. Gray, and Caroline E. Stackpole. Lutie C. Leavell, Ed. Macmillan, New York, ed. 14, 1961. 789 pp. Illus.

**Anthropology and Nutrition.** vol. 2, *Records of the American-Australian Scientific Expedition to Arnhem Land.* Charles P. Mountford, Ed. Melbourne Univ. Press, Melbourne, Australia; Cambridge Univ. Press, New York, 1960. 527 pp. Illus. \$19.50.

**A Bibliography of Eastern Asiatic Botany.** Supplement 1, Egbert H. Walker. American Inst. of Biological Sciences, Washington 6, 1960. 612 pp. Individuals and industrial libraries, \$18.50; AIBS members, \$16.50. Covers the years 1937 to 1958. Subjects and area covered remain essentially the same as in the original work; Chinese botanical literature is least well covered. Indexes include subject (general and regional) and systematic.

**The Biochemistry of Insects.** Darcy Gil-mour. Academic Press, New York, 1961. 355 pp. Illus. \$8.

**Concepts of Medicine.** A collection of essays on aspects of medicine. Brandon Lush, Ed. Pergamon, New York, 1961. 296 pp. \$8.50. Essays (26) reprinted from various sources.

**Encyclopaedia Zoologica, Illustrated in Colours.** pt. 3. Y. K. Okada *et al.* Hoku-ryukan Co., Tokyo, Japan, 1960. 266 pp. Illus. \$16.

**The Evolution of Man.** A brief introduction to physical anthropology. Gabriel Ward Lasker. Holt, Rinehart and Winston, New York, 1961. 255 pp. Illus. \$3.50.

**Existential Psychology.** Rollo May, Ed. Random House, New York, 1961. 126 pp. Paper, \$0.95. The papers, with the exception of certain parts added to the first chapter, were presented in a symposium at the annual convention of the American Psychological Association, 1959. Papers by Rollo May, G. Allport, H. Feifel, A. Maslow, and C. Rogers.

**Experimental Ecology of the Feeding of Fishes.** V. S. Ivlev. Translated from the Russian by Douglas Scott. Yale Univ. Press, New Haven, Conn., 1961. 310 pp. Illus.

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## Reports

### Formation of Diamond by Explosive Shock

**Abstract.** Samples of graphite have been recovered after exposure to explosive shocks of 300,000-atm estimated intensity. X-ray and electron-diffraction examinations prove the existence of diamond in this material. The mechanism proposed for the formation of diamond under these conditions is simple compression in the *c*-axis direction of the rhombohedral form of graphite.

In the course of a program to study the effects of explosive shocks on various minerals (1), samples of spectroscopically pure artificial graphite were exposed to shock pressures estimated at 300,000 atm for 1  $\mu$ sec (2). The recovered fragments, which microscopically resembled the original material, were rather brittle and did not possess the greasy feel of normal graphite when ground in a mortar. When a piece of this material was rubbed between a polished sapphire and a glass slide, fine scratches appeared on both the glass and the sapphire. X-ray diffraction patterns of the shocked graphite and of control specimens were made with filtered iron radiation in a Phillips camera 114-mm in diameter. The pattern of shocked graphite showed three additional lines, weak and slightly broadened, which could be indexed as the (111), (220), and (311) diamond reflections. These are the only possible reflections from diamond with filtered iron radiation. The line positions coin-

cided with a standard pattern of diamond powder made in the same camera, and the lattice spacing agreed with that reported by Swanson and Fuyat (3).

Some of this shocked graphite (4) was ground in a glass mortar to -325 mesh and centrifuged in bromoform, density 2.87 g/cm<sup>3</sup>. Since the respective crystal densities of graphite and diamond are 2.25 and 3.5, only particles containing at least 50 percent diamond by volume could settle. X-ray-diffraction, electron-diffraction, and microscopic examinations were made of the dense fraction. With filtered copper radiation all the permissible diamond lines were observed. However, the lines were so broadened that the K-alpha doublet could not be resolved even for the (331) reflection. Transmission electron-diffraction patterns of individual particles were made with a Hitachi model HU-10 apparatus. One of these particles, about 1  $\mu^3$  in volume, gave a pattern of partial-diffraction rings which corresponded to the first ten diamond reflections. Microscopic examination showed the particles to be small, generally 10  $\mu$  or less in diameter. In appearance, they resemble meteoritic carbonados.

Our most conservative estimates of temperature and pressure during the shock are well within the region of diamond stability. However, in the very short time at the pressure available in these experiments, it is unlikely that a mechanism involving wide-scale atomic movement and growth processes can be responsible for the graphite-diamond transition. A comparison of the structures of graphite and diamond reveals an available diffusionless mechanism for the transition.

The basic element of the graphite structure is a sheet of carbon atoms in which each atom is bonded to three other atoms at 120°C, forming a hexagonal network. These sheets are stacked in such a manner that alternate

atoms in a sheet lie above the centers of the hexagons in the sheet below. There are two simple stacking arrays that meet this condition. In the more common hexagonal form of graphite the stacking is . . . ABAB . . . ; that is, the atoms in the third sheet lie directly above the atoms in the first. In the rhombohedral form of graphite described by Lipsen and Stokes (5) the stacking is . . . ABCABC . . . ; that is, the atoms in the third sheet occupy a position symmetrically related to the first two.

It has been pointed out that the arrangement of atoms in diamond differs from rhombohedral graphite only in two respects (6). In diamond the sheets of hexagons are puckered and they are much closer together, 2.06 Å in diamond versus 3.35 Å in graphite. It appears that a simple compression in the stacking (*c*-axis) direction would suffice to convert rhombohedral graphite to a form very close to diamond. To complete the transition the sheets must now become puckered, which requires that each atom move only about 0.25 Å.

In the shock-loading experiments a commercial artificial graphite was used. X-ray patterns of this material reveal that it is predominantly hexagonal graphite, but there is considerable disorder in the structure. Comparison of our patterns with Franklin's published patterns (7) indicates that this graphite contains about 20 percent disordered structure. It is probable that some of this observed disorder is due to the presence of small domains of rhombohedral graphite.

We propose that the graphite-to-diamond transition observed in our experiments took place in properly oriented domains of rhombohedral graphite in the manner already described. In support of this mechanism is the fact that we have not yet been able to detect diamond in shock-loaded specimens of pure hexagonal graphite. The failure of Riabinin (8) to form diamond in a similar shock-loading experiment may have been due to a lack of the rhombohedral phase in his original material (9).

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**Instructions for preparing reports.** Begin the report with an abstract of from 45 to 55 words. The abstract should not repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to one 2-column figure (that is, a figure whose width equals two columns of text) or to one 2-column table or to two 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to contributors" [*Science* 125, 16 (1957)].



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9. This work was performed while one of us (J.C.J.) was a guest at the Poulter Laboratories. We thank Thomas C. Poulter, director of the Poulter Laboratories, for his advice and support. We also thank E. Anders, University of Chicago, for convincing us that the transition was feasible, and B. Alder of Lawrence Radiation Laboratory for some of his unpublished experimental results.

10 February 1961

## Role for Ganglionic Norepinephrine in Sympathetic Synaptic Transmission

**Abstract.** Transmission of nerve impulses in superior cervical sympathetic ganglia of cats and rabbits is markedly enhanced after reserpine-induced depletion of ganglionic norepinephrine. Transmission is also enhanced by administration of adrenergic blocking agents. In contrast, reserpine-induced release of ganglionic norepinephrine in animals pretreated with a monoamine oxidase inhibitor results in a pronounced depression of ganglionic transmission, which lasts until the ganglionic norepinephrine disappears. These results support the concept that norepinephrine in ganglia modulates the action of acetylcholine.

The fact that stimulation of preganglionic sympathetic nerves releases catecholamines from ganglia (1), together with the recent discovery that sympathetic ganglia contain considerable amounts of norepinephrine (2), prompts speculation on the role of the amine in the regulation of synaptic transmission. In this regard, Marrazzi and others have demonstrated that the injection of epinephrine and norepinephrine causes inhibition of ganglionic transmission (3). However, conclusions concerning the physiological role of a naturally occurring amine are questionable when they are based on studies of the injected substance. For example, the injection of histamine and even serotonin, a substance absent from sympathetic ganglia, also modifies ganglionic transmission (4).

We decided that a more direct approach to studying the role of norepinephrine in ganglia would be to compare synaptic transmission before and after depletion of the amine. The present report describes experiments which implicate ganglionic norepinephrine as a modulator of transmission in sympathetic ganglia. In these experiments changes in synaptic transmission were measured in cats and rabbits under chloralose anesthesia by applying graded electrical stimuli to the superior cervical sympathetic nerve and recording the electrical activity postganglionically before and after the intravenous injection of reserpine in various doses. The norepinephrine content of the superior cervical sympathetic ganglion was determined by a specific fluorimetric procedure which measures total (bound plus free) catecholamine and detects as little as 0.040  $\mu\text{g}$  of amine (5).

Reserpine in doses up to 0.2 mg/kg had no effect on ganglionic transmission; a definite increase was produced with 0.6 mg/kg, and maximal enhancement with 1.25 mg/kg. In control animals not given reserpine, the evoked potential remained relatively constant over a period of 20 hours. As shown in Table 1, facilitation of synaptic

Table 1. Norepinephrine concentration in cat superior cervical ganglia 4 hours after administration of various doses of reserpine. The drug, dissolved in water as the lyophilized phosphate salt, was given intraperitoneally, and the animals were killed 4 hours later. Norepinephrine concentrations are mean values, and numbers in parentheses indicate the number of animals.

Dose of reserpine (mg/kg)	Norepinephrine content ( $\mu\text{g/g}$ )
	7.1 (16)
0.005	6.9 (4)
0.025	5.0 (8)
0.050	3.0 (6)
0.200	1.0 (8)
0.600	< 1.0 (6)

transmission was associated with a reduction in the level of amine of more than 90 percent.

Figure 1 (typical of 12 experiments) shows the postganglionic response evoked by submaximal and supra-maximal stimuli at various times after administration of reserpine (2.5 mg/kg). After a latent period of about 4 hours the evoked potential was definitely higher than the control value; it continued to increase and was maximal in about 7 hours. The enhancement of the potential persisted throughout the 12 hours of the experiment. In

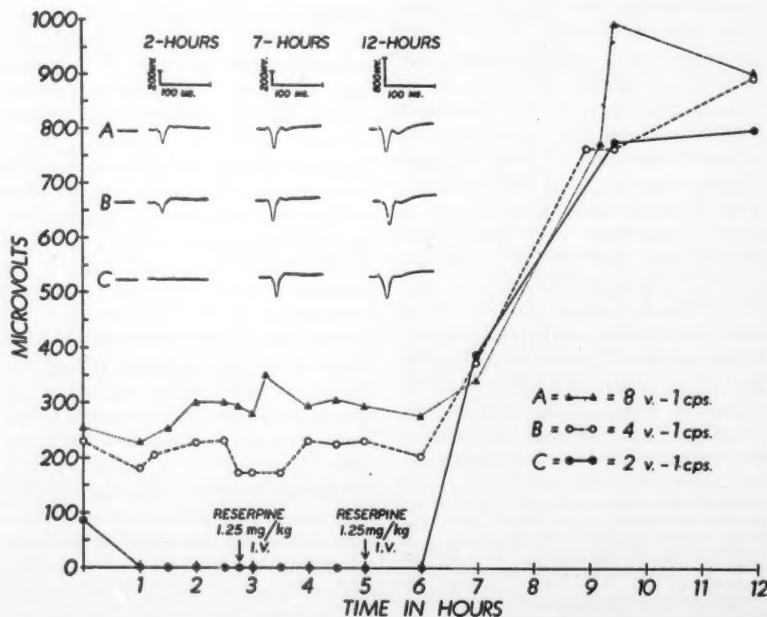


Fig. 1. Effect of reserpine on amplitude of postganglionic potential to graded electrical stimuli applied preganglionically to superior sympathetic ganglion. Stainless steel electrode pairs were used. Subthreshold (2 volts, 1 cy/sec, 0.01 msec) and supra-maximal (8 volts, 1 cy/sec, 0.01 msec) stimuli were applied in control period. Reserpine (2.5 mg/kg) was administered in divided doses at the indicated times. Records of 10 potentials, 1 second apart, measured at 2, 7, and 12 hours (upper left of the figure), indicate the reproducibility of the response. Note the reduction in amplification required to record the 12-hour response.

some experiments stimuli which produced no effect in the control period now evoked a potential equal to the greatest response produced by supra-maximal stimuli. In the rabbit, transmission of impulses across the superior cervical sympathetic ganglion was also facilitated by doses of reserpine that depleted ganglionic norepinephrine.

Experiments with cats given adrenergic blocking agents provided additional evidence of a role for norepinephrine in ganglionic transmission. Within 20 minutes after the intravenous injection of 1 mg of ergotamine per kilogram, the potential evoked by supra-maximal stimuli was facilitated by 200 percent or more for a period of at least 1 hour. Similar effects were produced with 20 mg of dibenamine per kilogram. Preliminary results have shown that ganglionic transmission is also facilitated by bretylium, a hypotensive drug that prevents the physiologic release of norepinephrine from sympathetic nerve endings (6).

Since transmission was enhanced in ganglia devoid of norepinephrine, the question could now be raised whether transmission would be inhibited in ganglia containing an accumulation of the free amine at the sites of release. A high level of free norepinephrine in ganglia was produced by treatment of cats with MO 911 (7), a potent monoamine oxidase inhibitor (8), and then by releasing the amine from storage by means of reserpine (1.25 mg/kg). As a result of blocking monoamine oxidase, the disappearance of the norepinephrine released in ganglia by reserpine was much slower than in animals given reserpine alone. Thus 1 hour after reserpine administration, the level of norepinephrine in the ganglia of cats given both the monoamine oxidase inhibitor and reserpine was 2.7  $\mu\text{g/g}$  (mean of four ganglia) compared with traces of amine in ganglia of animals given reserpine alone. Within 15 minutes after administration of the alkaloid, the potential evoked by submaximal stimuli was almost completely blocked; even the potential evoked by supra-maximal stimuli was markedly reduced. In 2 to 3 hours, when the free norepinephrine had finally diffused away, facilitation of the evoked potential was again observed.

The data presented here support the concept that norepinephrine as well as acetylcholine is implicated in transmission phenomena in sympathetic synapses. Cholinergic ganglionic transmission may be considered to effect the release of norepinephrine which in some unknown manner counteracts the effect of acetylcholine in the post-synaptic membrane. The reciprocal relationship between acetylcholine and

norepinephrine in sympathetic ganglia might be important in buffering large fluctuations in central sympathetic output. These results bring up the possibility that in the brain there is also a reciprocal relationship between the chemical transmitter and norepinephrine or serotonin, the monoamines serving as modulators of synaptic transmission rather than as transmitting agents.

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9 January 1961

### Ionium-Thorium Chronology of Deep-Sea Sediments of the Western North Pacific Ocean

**Abstract.** The rate of deposition of deep-sea deposits collected at the depths of 6215 to 8450 m in the western part of the North Pacific Ocean was estimated by means of the ionium/thorium ratio. The ratio was determined by an alpha-ray spectrometer. Results showed the rate of 0.5 to 0.8 mm/10<sup>3</sup> yr for the upper 10-cm layer below the sea bottom.

Pelagic sediments provide important records of geological processes in the ocean in the past. To estimate the rate of sedimentation, distribution of chemical elements with radioactivity has been extensively studied. The ionium-thorium geochronology (1-3) is one of the processes which is based on the assumption of simultaneous removal and deposition of two isotopes of thorium, ionium ( $\text{Th}^{230}$ , a member of the  $\text{U}^{238}$  series;  $T_1$ , 80,000 yr) and thorium ( $\text{Th}^{232}$ ;  $T_1$ ,  $1.4 \times 10^{10}$  yr), from sea water. Another assumption of this method is that the Io/Th ratio remains constant in a given water mass over the period under consideration. The contribution of thorium and uranium from detrital minerals of continental

or volcanic origin must be negligible or can be accounted for.

Recently, Goldberg and Koide (2) developed the alpha-ray spectrometric method for determination of ionium and thorium in deep-sea deposits. They have found an exponential decrease in the Io/Th ratio with the depth of burial which indicates that the ionium may not be redistributed after deposition. Rona, Akers, and Parker (3) also applied the same method to the age determination of North Atlantic deposits. In our laboratory, attempts have been made to obtain ages, by means of the Io/Th ratio, of deep-sea sediments of the western North Pacific collected at various depths from aboard the research vessel, M.S. *Ryofu-maru*.

One to two grams of dried sediments were subjected to leaching with a hot solution of a mixture of hydrochloric and perchloric acid. The residue was separated by centrifuge, and leaching was repeated. The solution was nearly dried up on a sand bath and dissolved again in dilute hydrochloric acid from which silica was removed by filtration. The acidity of the filtrate was adjusted to a 3f solution of hydrochloric acid.

Thorium isotopes were isolated from the filtrate with a cation-exchanging resin. The thorium isotopes have a strong tendency to adsorb selectively on the cation exchanger, while there is little adsorption of aluminum, iron, and other cations in the hydrochloric acid media of high concentration. The cation exchanger of HR form, Amberlite IR-120 of 100 to 200 mesh, was used in a column 4 mm in diameter and 5 cm long. A solution was passed through the column at a flow rate of approximately 1 ml/min. The column of the resin in which thorium isotopes were adsorbed was rinsed with the hydrochloric acid solution (4f) and water. Thorium isotopes were subsequently eluted with 0.5M oxalic acid. The thorium contained in the effluent was plated on a platinum disk 4 cm in diameter; this was followed by ignition to remove oxalic acid. Another thorium isotope,  $\text{Th}^{234}$  ( $\text{UX}_1$ ), which was prepared by the method of Cowan (4), was used as a radioactive tracer to determine the chemical yield. The recovery of the thorium isotopes was checked each time with the activity of beta rays of  $\text{Th}^{234}$ . The results of tracer experiments gave a yield ranging from 70 to 97 percent.

The intensities of the alpha rays of  $\text{Th}^{230}$  and  $\text{Th}^{232}$  plated on the platinum disk were measured with an alpha-ray spectrometer, which consists of a Frisch grid-ionization chamber (Tracerlab), combined with a high-gain amplifier and a pulse-height analyzer. Since alpha-particles of Io and Th have dominant

Table 1. Ionium-thorium ratio and rate of deposition of cores from the western North Pacific Ocean.

Depth interval (cm)	Io/Th	Rate of sedimentation (mm/10 <sup>3</sup> yr)
<i>Sample JEDS-1-R; 30°24.6'N, 124°18.7'E; 8450 m (Ramapo Deep)</i>		
0-3	3.4 ± 0.2	0.5 ± 0.04
3-7	2.0 ± 0.1	.3 ± .04
12-15	0.2 ± 0.1	
<i>Sample JEDS-2-C<sub>2</sub>; 42°48.0'N, 147°59.0'E; 8005 m</i>		
0-4	4.0 ± 0.2	.8 ± .05
4-8	2.6 ± 0.1	
<i>Sample JEDS-3-D<sub>1</sub>; 29°50.0'N, 147°28.3'E; 6215 m</i>		
0-5	6.2 ± 0.5	.5 ± .04
5-10	2.8 ± 0.2	.3 ± .04
10-15	0.4 ± 0.1	

energies of 4.6 to 4.7 and 3.98 Mev, respectively, they can be measured separately with a pulse-height analyzer. Thus the abundance ratio of Th<sup>230</sup> to Th<sup>232</sup> was obtained as the ratio of alpha-counts at each energy level.

The results of analyses of Io and Th in three cores of deep-sea sediments collected from the depth of 6215 to 8450 m in the western North Pacific are given in Table 1. Exponential decrease in the Io/Th ratio with the depth of burial is observed in each sample. Thus, it may be said that, during the time period of the last 100,000 yr, the sedimentation environment in this region has not differed largely from that of the present.

From these analytical results the rate of sedimentation of approximately 0.5 to 0.8 mm/10<sup>3</sup> yr was obtained in the upper 10-cm layer below the sea bottom. These values are of the same order of magnitude that Goldberg and Koide (2) gave to the deposits of the Eastern Pacific and that Pettersson (5) gave to the sediments from near Tahiti Island in the South Pacific.

Baranov and Kuzmina (6) gave a much more rapid rate of deposition of 10 to 30 mm/10<sup>3</sup> yr in the western region of the North Pacific. However, there are some doubts about their analytical results and the estimation of the rate of sedimentation.

According to Goldberg and Koide, the Io/Th surface ratios in the Eastern Pacific clays can be classified into two groups. One is found in the region between the Aleutian Islands and Hawaii with the value of the Io/Th ratio of about 15; the other group has the value of about 35, and is found from the region between 120°W and 140°W longitude and between 40°N and 40°S latitude. However, our results regarding the western North Pacific cores show that the Io/Th surface ratio ranges from 3 to 6, which is considerably smaller than that in other areas of the

Eastern Pacific (7). This difference is difficult to explain at present, but it may be noted that Goldberg, Patterson, and Chow (8) suggested the similarity between the distribution patterns of isotopes of lead (Pb<sup>206</sup>) in manganese nodules and the Io/Th ratio in the deposits in the Pacific. In this respect, they gave the extraordinarily smaller value of the lead isotope for the sea area near the Japanese islands (9, 10).

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27 December 1960

#### Compositional Categories of Ancient Glass

*Abstract.* From chemical analyses of ancient glasses found in Europe, Western Asia, and Africa from roughly the 15th century B.C. until the 12th century A.D., five main compositional categories have become apparent. With the possible exception of lead glasses which are only occasionally encountered in finds from this period, each of the main categories was prevalent over a wide geographic area for a period of at least several centuries. The categories are described in terms of the expected ranges of concentrations of the five elements, magnesium, potassium, manganese, antimony, and lead, which most clearly differentiate the groups.

A series of approximately 200 fragments and powdered samples of ancient glass has been collected through the agency of the International Committee on Ancient Glass and analyzed chemically at Brookhaven National Laboratory. The specimens were selected to

represent a cross section of glass produced in the Middle East, Africa, and Europe after the inception of hollow glass manufacture during the second millennium B.C. Our terminal date in Europe coincides with the introduction of postassium-rich compositions in about the 10th century A.D. We follow Islamic glass to the development of its splendid enameled bottles and lamps about two centuries later. The specimens were generously provided from the collections of 20 museums, universities, and related institutions, 12 active sites of archeological excavations, and several individuals. Most of these specimens were excavated under scientific supervision; others were of known provenance to the degree, at least, that the locations of their discovery were recorded. Occasionally the data on certain groups of specimens were supplemented by analysis of objects of unknown origin but showing a high degree of conformity in style. Otherwise, specimens of unknown origins have been investigated only where equally valid justification was present.

The purpose of this research has been to reveal any systematic compositional differentiations in ancient glass, whether based on regional or chronological classifications. The work represents an initial approach to a systematic technological study of ancient glass (1). We have placed the principal emphasis on the common types of clear glass, to avoid undue bias of color chemistry or the distractions of highly atypical specialties in ancient glass. Only occasionally have deliberately colored specimens been examined.

The glasses were analyzed for 26 elements by a combination of three techniques: arc spectrography, flame photometry, and colorimetry, the spectrographic plates being read quantitatively by means of a photoelectric densitometer. The resulting analyses were found to be reproducible with standard deviations within 20 percent of the reported values.

On the basis of these analyses, five main categories of ancient glass have become apparent, not considering ancient production in the Far East. Each is characterized by a chemical composition distinctly different from that of the others. A preliminary report of these groupings is presented here (2).

The most significant chemical differences between these five groups of ancient glass are presented in Table 1 and Fig. 1. No finality is claimed for these groups. Further research, for example, will surely reveal transitional and marginal groups. Within a group, a plot of the occurrence of specimens against the logarithm of concentration closely approximates a chance (Gaussian) distribution. The significance of



Table 1. Mean concentrations of the oxides that best characterize ancient glass.

Glass group	Specimens (No.)	Mean percent concentrations and standard deviation ranges				
		Magnesium MgO	Potassium K <sub>2</sub> O	Manganese* MnO	Antimony Sb <sub>2</sub> O <sub>3</sub>	Lead PbO
Second millennium B.C.	15	3.6 (4.6-2.9)	1.13 (1.89-0.69)	0.032 (0.046-0.021)	0.058 (0.32-0.011)	0.0068 (0.048-0.0010)
Antimony-rich	34	0.86 (1.24-0.60)	0.29 (0.47-0.17)	0.022 (0.035-0.014)	1.01 (1.93-0.53)	0.019 (0.077-0.0047)
Roman	73	1.04 (1.47-0.73)	0.38 (0.63-0.22)	0.41 (1.60-0.10)	0.040 (0.089-0.018)	0.014 (0.057-0.0033)
Early Islamic	66	4.9 (6.5-3.6)	1.45 (2.2-0.94)	0.47 (1.07-0.21)	0.021 (0.035-0.012)	0.0088 (0.047-0.0016)
Islamic lead	6	0.33 (0.47-0.24)	0.026 (0.051-0.013)	0.022 (0.031-0.016)	0.081 (0.19-0.035)	36 (40-33)

\* Some glasses with a characteristic dark blue or violet color contain considerably more manganese than colorless glasses of the same type. It has been assumed that manganese was added deliberately to such glasses as a colorant, and they have been excluded in calculating the average manganese values.

this is that the chance deviations from the most probable concentrations are of a fractional nature. In light of this observation it is reasonable to regard the average and the standard deviation of the logarithms of concentrations as most correctly describing the probability of the occurrence of concentrations within a group. The mean concentrations so obtained are in a sense geometric means of the concentrations. The means and deviation ranges in Table 1 and Fig. 1 were obtained in this way. The lengths of the diamonds in Fig. 1 indicate the limits of the logarithmic standard deviation ranges.

Glass of the second millennium B.C. group (15th century B.C. to about 7th century B.C.) is a typical soda-lime glass with a high magnesium content, examples of which, predominantly from Egyptian finds, have been reported in earlier studies (3). It is now indicated that this composition was characteristic of glass produced or used throughout the Mediterranean area during the second millennium B.C., as our specimens come from Egypt, Mesopotamia, Greece (Mycenae), and Persia (Elam). This early group is not quite as compositionally consistent as later ones. For example, occasionally sizable concentrations of lead or antimony oxide appear to have been added to the basic glass mixtures.

Glass of the antimony-rich group (about 6th century B.C. to about 4th century A.D.) is characterized by a lower potassium and magnesium content and by the consistent appearance of antimony in high concentration. Glass of this over-all composition has not been reported previously. If we judge by the areas of the finds, it represents the composition used in Greece (Olympia), Asia Minor (Gordion), and Persia (Persepolis) during the 5th and 4th centuries B.C., and the type apparently continued to be popular in areas from the Euphrates eastward (Dura Europos and Begram in particular) during the ascendancy of Rome. Within areas dominated by

Rome this glass ceased to be prevalent, being encountered only occasionally.

The Roman group (about 4th century B.C. to 9th century A.D.) appears to represent the normal composition of "Roman glass" and was probably typical of the Syrian coastal cities, Egypt,

Italy, and the western Provinces, remaining with little change through the Frankish and Saxon periods. The composition is similar to that of the antimony-rich group except that the antimony content is much lower and in most cases the manganese content cor-

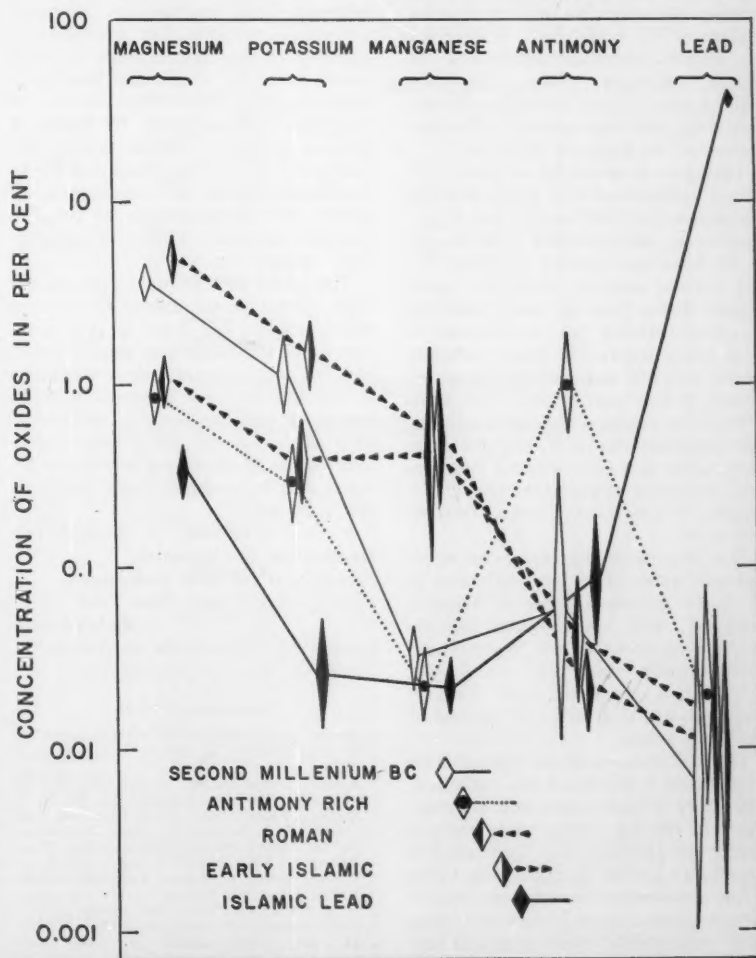


Fig. 1. Standard deviation ranges for concentrations of various metal oxides in the five main categories of Western ancient glass.

respondingly higher. This suggests the possibility that the distinction represents simply the use of one decolorant instead of another. Certainly coloration due to iron is often effectively suppressed in glasses of both compositions.

Glasses of this "Roman" composition have been reported in earlier analyses. Matson (4) pointed out the essential differences between this glass and early Egyptian glass, suggesting the possibility that the change from one composition to the other was occasioned by the advent of glassblowing. Now, however, it appears that at least in eastern areas the early glass was superseded by the antimony-rich composition several centuries before the appearance of mass-produced blown glass.

The early-Islamic group (introduced 8th–10th century A.D.) is the one comprising what might be called "Islamic soda-lime glass." It is marked by a return to the higher magnesium and potassium concentrations of the second millennium B.C. group but, in general, without showing the low manganese content of the early glass. The principal sources of these specimens included Nishapur, Susa, Quadrisia, Kish, Raqqa, Fostat, Sabrah, and various Iraqi sites represented in the collection of the Baghdad Museum.

This glass is so similar to that of the second millennium B.C. group that the assumption has been voiced that it represents an uninterrupted continuation of the same glassmaking tradition (5). The present analyses, however, would suggest that a lapse of many centuries occurred between the production of these two categories of glass. Certainly glasses of both the antimony-rich and Roman groups were produced in some of the areas destined to become Islamic. The possibility, however, that the early formulation was used without interruption in certain regions (Mesopotamia, Parthia, or Central Asia) merits investigation.

The four preceding categories represent only relatively minor variations in the basic soda-lime glass of Western antiquity. The distributions of the major components, silicon, sodium, and calcium oxide, essentially overlap for the different categories with standard deviations of the order of 25 percent of the mean values.

The identification of the Islamic lead-glass group (introduced 8th–10th century A.D.?) is based upon only six analyses, but the six glasses came from a variety of sources and yet possess remarkably similar compositions. Glass of this composition has not been singled out previously. Islamic lead-glass contains considerably more lead and less alkali and lime than most New Kingdom high-lead glass. It is distinctly

different from the lead-barium Chinese glass reported by Seligman and Beck (6) and also from the two main types of 11th–13th century A.D. Russian lead glasses described by Bezborodov (3).

Out of the 26 elements determined, only the five that show the clearest differences between the major glass categories are listed in Table 1. Some of the other elements confirm these differentiations, others are present in the same range of concentration in all except the lead glasses, and some are present in small erratic concentrations that have not yet revealed a correlation with provenance. Indications of some regional correlations within the main categories have been noted and are being explored. For example, Islamic glass from Iraq and northwestern Iran appears to have significantly less manganese than other Islamic glass. Also, high-antimony glass found at Persepolis can be differentiated from fundamentally similar and contemporary glass excavated in Greece and Asia Minor upon the basis of its relatively low contents of titanium, zirconium, and lead. The possibility of determining the concentration of additional elements, which are present in concentrations below the limits of spectrographic sensitivity, by means of neutron activation analysis is being investigated. Also, it has been possible to determine without the consumption of sample the concentrations of the five elements of Table 1 by x-ray fluorescence analysis.

The initial and terminal dates of the main groups should eventually become more precise, and some of the main compositional changes in ancient glassmaking will probably be explainable in terms of the raw materials utilized, improved furnace designs, and other shop improvements. An ultimate objective will be to pin down individual deposits and to establish trade routes in raw materials (7).

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3 October 1960

## Zinc-65 in Marine Organisms along the Oregon and Washington Coasts

**Abstract.** The concentration of zinc-65 in marine animals and plants near the mouth of the Columbia River is presented. Amounts of radiozinc found in the biota diminished rapidly with the distance from the river mouth. The highest levels were found in plankton, algae, and mollusks. Of the human foods, oysters exhibited the highest levels.

Zinc-65, a nonfission product commonly formed by nuclear detonations and nuclear reactors, was found in pelagic fish collected in 1954 near the Pacific Proving Grounds after the Castle series of weapon tests (1). It was subsequently reported in tuna (2), marine plankton (3), mollusks (4), and reef fishes (5) of the western Pacific. In these marine organisms  $Zn^{65}$  was responsible for up to 40 percent of the total radioactivity and in most instances was more abundant than any of the fission products. Radiozinc has also been found in marine shellfish from the Atlantic coast of the United States (6).

This radionuclide is present in Hanford reactor effluents and is one of the dominant radioisotopes in aquatic organisms inhabiting the Columbia River downstream from reactors (7). It is also found in agricultural products which are irrigated with river water taken from the Columbia at a point approximately 45 miles down river from the reactors (8, 9).

The amounts of  $Zn^{65}$  which enter the Pacific Ocean through the Columbia River are dependent on several factors, including reactor-operating levels and river flow. Concentrations of  $9 \times 10^{-9}$  to  $1.5 \times 10^{-7} \mu\text{C}$  of  $Zn^{65}$  per cubic centimeter of Columbia River water were measured at Vancouver, Wash., located about 90 miles from the river mouth, during the last half of 1959 and the first quarter of 1960 (9, 10). Total discharge of  $Zn^{65}$  based on these measurements ranged from 8 to 55 curies of  $Zn^{65}$  per day; this would result in an equilibrium value of about 7000 curies

in the ocean. A recommended rate of release of noncontained  $Zn^{65}$  into the ocean is  $1.4 \times 10^4$  c/yr or approximately 40 c/day (11).

The dispersion pattern of the Columbia River in the ocean is not well defined. In general the flow in summer, based on salinity measurements, is toward the southwest and may be detected for distances up to 200 miles from the river mouth (12). Flow in winter is generally toward the north along the coast of Washington. Factors such as wind direction and velocity, tidal amplitude and seasonal variation in volume discharge of other coastal streams in the area will affect the along-shore movement of Columbia River water.

To investigate the dispersion and accumulation of radioelements from the Hanford Atomic Products Operation in the marine biota, various kinds of plant and animal life were sampled along the coasts of Washington and Oregon during September 1957, April 1959, and April and July 1960. Early collections were made within 40 miles of the river mouth while later surveys included samples from locations up to 250 miles distant. Most of the material collected was obtained from the intertidal zone and included birds, fish, crustaceans, mollusks, algae, and plankton.

Samples were ashed at  $550^\circ C$  for approximately 24 hours before they were counted in a 256-channel gamma-ray analyzer, which was equipped with a 3-in. diameter by 3-in. high sodium iodide crystal.

Zinc-65 was the dominant gamma-emitting radioelement in all samples analyzed, and highest concentrations occurred in mollusks, algae, and plankton. Values for representative kinds of algae and mollusks are given in Fig. 1. The concentration of  $Zn^{65}$  in the biota was highest at the mouth of the river and decreased very rapidly with the distance from there. Mussels from locations 100 miles distant from the river mouth contained less than 10 percent of the amount of  $Zn^{65}$  found in mussels at the mouth. No appreciable differences in levels of radiozinc with respect to direction from the river mouth were noted, a possible indication of nearly equal distribution of river water to both Oregon and Washington coasts at the time of measurement.

Interspecies differences in concentration of radiozinc were most evident in the organisms collected near the river mouth with highest levels found in plankton, attached algae, and mussels. In 1959 the amount of  $Zn^{65}$  in these forms was 80, 110, and  $100 \mu\mu c/g$  (wet weight), respectively. Both the algae and the plankton have high ratios of surface area to body weight,

which possibly makes adsorption and entrapment of particulates an important factor in the amounts of  $Zn^{65}$  found in these forms. Mollusks are very rich in zinc (13), and oysters contain greater amounts than other bivalves (13, 14). As pointed out by Chipman *et al.* (14), the amount of zinc concentrated in the soft tissues of oysters is directly related to the amount available in the water in which they live. The concentration of radiozinc in crabs, fish, and marine birds was approximately one-tenth that found in algae or mussels.

Although it is rather difficult to evaluate the change in concentration of  $Zn^{65}$  with time because samples were not collected at the same season of the

year, there has been an increase since the first measurements were made in 1957. Little change is apparent between 1959 and 1960, however.

Of the marine organisms from near the mouth of the Columbia River commonly used for food by man, oysters had the highest concentration of radiozinc, and razor clams were second highest in this respect. Willapa Bay, Washington, one of the major oyster-producing areas of the Pacific coast, is located approximately 40 miles from the mouth of the Columbia River.

On the basis of limits for persons outside a controlled radiation zone, as suggested in Handbook 69 (15), and the concentration of  $34 \mu\mu c$  of  $Zn^{65}/g$

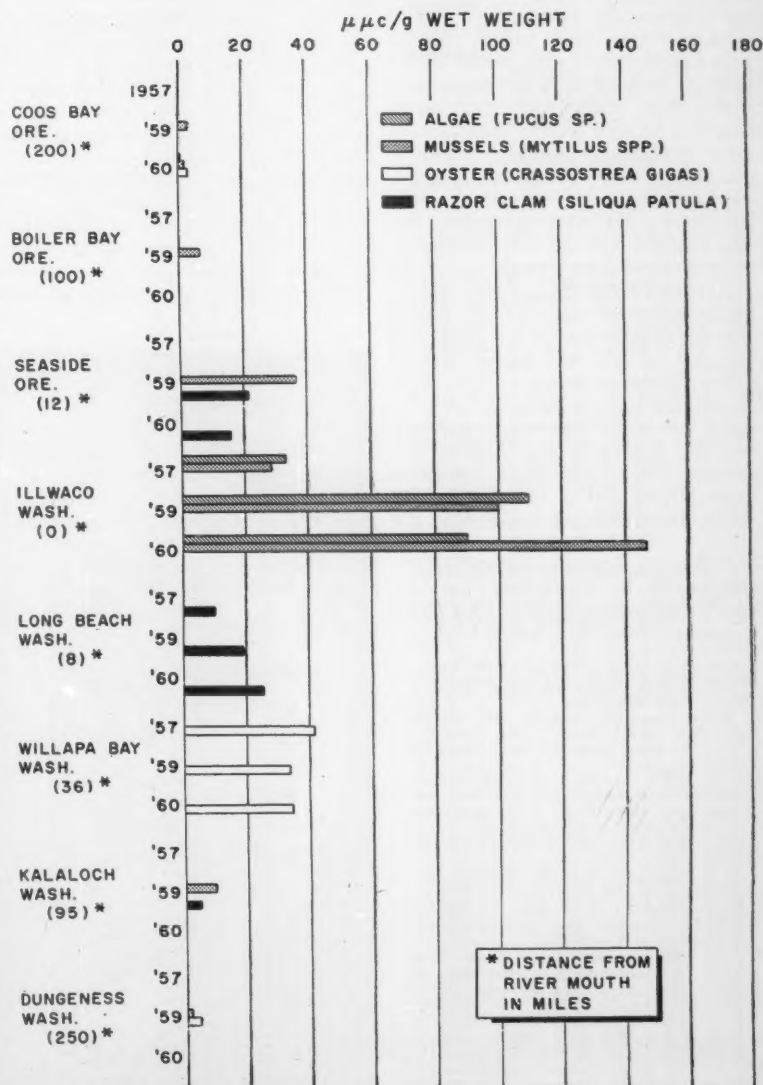


Fig. 1. Concentration of  $Zn^{65}$  in marine organisms near the mouth of the Columbia River.



found in Willapa Bay oysters, a consumption of this seafood at the rate of 100 lb/week would be necessary to produce a maximum permissible concentration of  $Zn^{65}$  ( $6 \mu\text{C}$  total body burden). Although this concentration of radiozinc is higher than that reported in other human foods in the United States [for example,  $0.32 \mu\text{C/g}$  in beef liver from Nevada (16),  $0.18 \mu\text{C/g}$  in Atlantic coast oysters (6), and  $11 \mu\text{C/g}$  in beef grazed on land irrigated with Columbia River water (8)], it is substantially below levels that would produce a maximum permissible concentration in man even if oysters were the sole source of animal protein in the diet (17).

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19 December 1960

## High-Rate Laboratory Filtration with Büchner Funnels

**Abstract.** A method is described for greatly increasing the efficiency of Büchner funnels by utilizing a much larger fraction of the filter paper surface. The method also makes it possible to use Millipore filters efficiently on Büchner funnels.

Büchner funnels, as commonly used, have the disadvantage that filtration is limited to those areas of the filter paper which lie directly over the holes in the porcelain plate. When these areas, which represent only a small fraction of the paper surface, become clogged, filtration stops. The filter paper disk studded with mounds of residue is a familiar sight.

A very simple but extremely effective way of fully utilizing the total area of the filter paper has been devised in this laboratory. It consists of interposing a disk of screening (Fiberglas window screening is good because it will not ravel) between the paper and the pierced porcelain plate of the funnel. The paper is centered over this disk (which is about  $\frac{1}{4}$  to  $\frac{1}{2}$  in. smaller in diameter than the paper), is wet, and its edge is smoothed onto the porcelain surface. Thus the main portion of the

paper is kept off the porcelain plate and rests instead on a surface having many openings. The holes in the porcelain serve only to carry off the filtrate.

The result is that the rate of filtration is speeded up greatly, the quantity of suspension which can be filtered by a single sheet of paper is increased markedly, and, instead of the paper surface being covered with mounds of residue, the whole surface is uniformly coated (Fig. 1).

Typical results include the filtering with an 11-cm funnel, of 500 ml of a turbid, opalescent bog water in 5 min by using the screen, compared with 42 min for the usual procedure; and the filtering of 1 liter of a silica suspension (5 g/lit.) in 2 min by using the screen, compared with 9 min for the usual procedure. On one occasion 900 liters of lake water were filtered with a 24-cm Büchner funnel, a feat which we would not even have contemplated earlier because of the time it would have taken.

Filtering efficiency in terms of removal of suspended matter is not substantially affected by the screen. A sample of turbid bog water (51 percent transmission of blue light) exhibited about the same degree of clarification when filtered with No. 42 Whatman

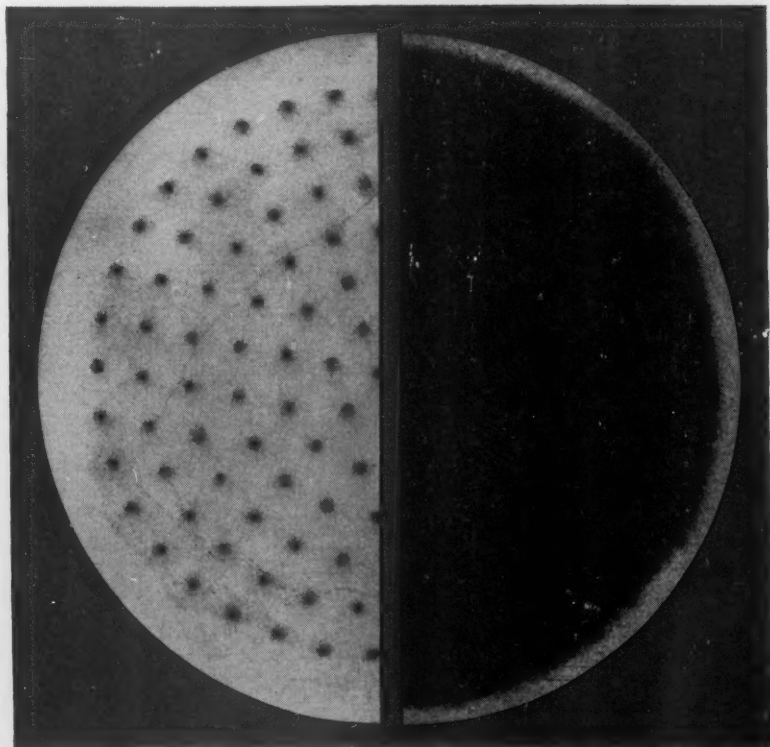


Fig. 1. Filtration of bog water with a Büchner funnel. Left, usual procedure; right, improved procedure.

paper by the usual procedure (73 percent transmission) as by the improved method (72 percent transmission).

The method, while devised initially for paper filters, is equally applicable to Millipore filters which thus can be used without the need of special holders. The 900 liters referred to above were subsequently filtered on the same funnel through Millipore filters cut to the appropriate size.

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### Instrumental Conditioning of Jugular Self-Infusion in the Rhesus Monkey

**Abstract.** A technique is described for self-infusion of pharmacologic agents in solution through a permanently indwelling jugular catheter in the rhesus monkey. The results of an experiment utilizing this technique demonstrate that an instrumental lever response can be conditioned, extinguished, reconditioned, and brought under stimulus control and reward-schedule control with saline self-infusion as the reinforcing stimulus.

Relatively few psychopharmacological studies have focused upon a systematic analysis of the reinforcing properties of chemical compounds with known behavioral effects (1). Technologically, the many problems associated with drug administration and the arrangement of appropriate contingent relationships involving behavioral indicators have made experimental investigations in this area difficult to conceive and carry out. It is the purpose of this report to describe the development of a technique of potential value for investigating the reinforcing properties of drugs in laboratory animals and to present the results of an experiment designed to demonstrate its methodological feasibility. Specifically, the present report is concerned with the development of a technique for self-infusion of pharmacologic agents in solution through a permanently indwelling jugular catheter in the rhesus monkey and describes several aspects of the conditioning of an instrumental lever-pressing response with saline self-infusion as the reinforcing stimulus.

Two rhesus monkeys, restrained in chairs, served as subjects. Crackers were continually available to them. After surgical implantation of permanently indwelling catheters in the internal jugular vein of each monkey, continuous recordings of operant levels of

responding on a lever switch (a modified telegraph key mounted on the chair within easy reach of the monkey's paw) were taken for both animals during an 8-day period (4 days of water available alternated with 4 days of no water available). After this operant level determination under both satiated and water-deprived conditions (Fig. 1A), the water bottle was removed and each lever response was programmed to activate an infusion pump and produce an injection of saline through the indwelling catheter. Under this condition of continuous reinforcement, each lever response during a 4-hour daily session delivered 1.95 ml of saline at the rate of 1 ml/min. Lever responses which occurred during a saline infusion were recorded, but otherwise had no consequence. A house light was on during each test session and off at all other times. With both animals, introduction of the saline infusion reinforcement contingency produced a significant increase in the lever-pressing response rate which remained consistently above operant levels (Fig. 1B) and which exhibited the typical characteristics of behavior under continuous reinforcement conditions. The subjects self-infused a daily average of 65 ml of saline during this phase of the experiment.

Extinction of the instrumental lever-pressing response was observed in both monkeys after discontinuation of the saline infusion (Fig. 1C). With only the tube from the pump to the catheter disconnected and all other aspects of the circuit in operation, a typical lever-pressing extinction curve was generated by both monkeys with a concomitant return to operant level response rates. After reconditioning of the self-infusion behavior by replacing the pump connection (Fig. 1D), both monkeys were

provided with an *ad libitum* supply of water through an easily accessible bottle and mouth spout. Under these conditions of free access to water by way of the normal oral ingestion route, a marked decline in the self-infusion response rate was again observed for both monkeys (Fig. 1E). This finding indicates that the reinforcing properties of normal saline infused in this manner are at least partially sensitive to variations in "drive" level.

In the final phase of this experiment an attempt was made to bring the instrumental self-infusion behavior under exteroceptive stimulus control. Lever responses were reinforced with saline infusion only in the presence of a dim light stimulus presented on a panel in front of the monkey. Responses in the absence of the light were not reinforced. Five-minute periods of dim light were alternated with 5-minute periods of no light during each 4-hour daily session. After several days of exposure to these conditions, the response rates and volume of self-infused saline recorded during the dim light condition approximated levels obtained during the previous continuous reinforcement sessions. The response rates in the absence of the light approximated the operant level (Fig. 1F). Preliminary observations have also indicated that such self-infusion responding can be brought under reinforcement schedule control by requiring a fixed ratio of lever responses to produce each saline injection. Introduction of such a ratio requirement produced a marked increase in the response rate over both operant and continuous reinforcement levels (Fig. 1G).

These findings indicate quite clearly that the self-infusion of a chemical compound in solution can serve as a

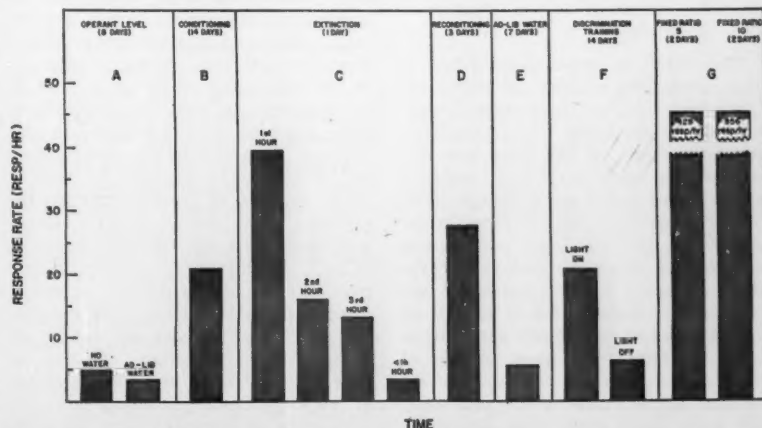


Fig. 1. Average response rate, in responses per hour, during the various phases of the experiment.

reinforcing stimulus for the establishment and maintenance of an instrumentally conditioned lever-pressing response. It is also clear that instrumental behavior maintained under these conditions is sensitive to changes in so-called "drive" states, and that it can be brought under the control of both discriminable exteroceptive stimulus conditions and reinforcement schedule contingencies. Future exploitation of this technique will permit an experimental analysis of the reinforcing properties of many pharmacologic agents under varying conditions of behavioral control.

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25 January 1961

### Suppression of Male Characteristics of Mosquitoes by Thermal Means

**Abstract.** Dimorphism in *Aedes stimulans*, a northern floodwater mosquito, may be decreased possibly to obliteration by exposing larvae for most of their lives to abnormally high temperature. Determiners for maleness fail to express themselves when larvae are exposed to a temperature of 29°C throughout their lives. Not only are male characteristics eliminated, but normal female ones such as ovaries, spermathecae, and cerci develop. The resultant adult is structurally a female. Forms showing characteristics of both sexes occur when the number of days of exposure to 29°C is lessened.

The sexes of mosquitoes differ in appearance in a number of easily recognizable ways, as has been well summarized by Snodgrass (1). Anteriorly, the appendages of the head are distinctive for each sex. The antennae and palpi of males are strikingly more hirsute than their counterparts in females. On the other hand, mouth parts are reduced from the female complement of seven to two functional appendages. Caudally, the male has an elaborate set of copulatory appendages, while the female has none. A pair of flaplike cerci marks the caudal portion of the female externally. Internally, the males have testes, vasa deferentia, seminal vesicles, and a bilobed accessory gland. The female has ovaries,

Table 1. Effect of high-rearing temperature on sexual characteristics of genetically intended males of *Aedes stimulans* in the laboratory. M and F, normal male and female; a.m. and a.f., abnormal male and female; +, present; -, absent.

Imaginal parts	Sex at serial-rearing temperatures of 24° and 29°C								
	Days at 24°C:		8	5	4	3	2	1	0
	Days at 29°C:		0	3	4	5	6	7	8
	<i>Internal parts</i>								
Gonads	M	M	M	M	M	F	F	F	
Tubes to gonads	M	M	M	M	M	M,F	F	F	
Sperms	+	+	+	-	-	-	-	-	
Spermathecae	-	-	-	-	-	+, -	+	+	
Accessory gland	M	M	M	M	M	M,F	F	F	
	<i>Caudal parts</i>								
Parameres	M	M	M	a.m.	a.m.	-	-	-	
Phallosome	M	M	M	M	-	-	-	-	
Genitalia position	M	a.m.	a.m.	a.m.	a.m.	F	F	F	
Cerci	-	-	-	-	a.f.	F	F	F	
	<i>Cephalic parts</i>								
Antennae	M	M	M	F	F	F	F	F	
Palpi	M	M	a.m.	a.m.	a.m.	a.m.	a.f.	a.f.	
Mouth parts	M	M	M	F	F	F	F	F	

oviducts, spermathecae, and a small saclike accessory gland. Significant changes in these structures have been brought about by treating larvae to abnormally high temperature (2).

Mosquitoes showing external characteristics of both sexes have been collected in different parts of the world. Such anomalies, called intersexes by Kitzmiller (3), number less than 40. Most of them have come from northern latitudes, and in some instances two or more individuals have been collected from the same vicinity at approximately the same time. The facts of location and repetitive occurrence suggest possible genetic or environmental causes for the anomalies. Unfortunately, specimens have been collected so infrequently that little more can be inferred.

*Aedes stimulans*, a snow-pool mosquito common to Canada and northern latitudes of conterminous United States, has been induced to express marked intersexual tendencies under laboratory conditions. The two sides of the responding genetic males are affected alike, and no unilateral responses have been elicited. When a uniformly mixed population of larvae (Table 1) is separated into two lots immediately after hatching and is exposed in one instance to a continuous temperature of 24°C and in another to one of 29°C, marked differences between the resulting males always occur. Genetically intended males from larvae reared at 24°C develop antennae, palpi, mouth parts, external genitalia, accessory glands, seminal vesicles, vasa deferentia, and testes that are normal in appearance and function. Larvae of genetically intended males when reared at 29°C without exception are like females in all respects except for slight differences in palpi. Internally, the anomalous males have ovaries, oviducts,

and spermathecae, and they lack testes, vasa deferentia, seminal vesicles, and bilobed accessory glands. The ovaries have globular egg chambers indistinguishable from those of young genetic females (see 4).

Abnormally high temperature exerts its modifying effect on larvae of potential males according to the duration of exposure (Table 1). High temperature applied late (last 3 days) in larval life produces no structural defects but prevents rotation of genitalia to the copulatory position. An extension of exposure to high temperature to include the last 6 days of larval life causes a series of changes that produces intersexes. Larvae exposed to 29°C for 7 days or more grow into apparent females, some of which have been inseminated by normal males. Insemination was determined by examining the spermathecae under a compound microscope for the presence of sperms.

Larvae that bear female determiners are unaffected by a temperature of 29°C. They give rise to females that are normal in appearance, copulate readily by the artificial means described by McDaniel and Horsfall (5), feed on blood, and develop eggs in a normal manner.

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23 January 1961



## Simple Method for Measuring Heart Vector of Isolated Animal Hearts

**Abstract.** The spatial dipole moment of a perfused animal heart suspended at the center of a fluid-filled sphere can be found in magnitude and direction to a good approximation by three sets of bipolar measurements. The method has been applied in finding the vectorcardiograms of turtle and rabbit hearts.

The method for measuring the heart vector of isolated animal hearts is based upon the facts that (i) the potentials at the surface of a fluid-filled insulating sphere due to a dipole at the center are equal to 3 times the values they would have at the corresponding points if the medium extended to infinity, and that (ii) at sufficiently remote points the heart's electrical activity is determined by its resultant dipole moment.

The first fact is not very well known outside the field of electrocardiology and cannot be found explicitly stated in textbooks of electricity or hydrodynamics. The first statement of the relation was apparently made by Canfield (1), but the derivation was not shown. Wilson (2) derived the equation by differentiating the free-space equation and setting the derivative equal to zero at the boundary. Hicks (3) made the first treatment of a source and sink at any points within a sphere and showed that the image of a source is a source at the inverse point plus a line sink distribution from the inverse point to infinity. The equation he presented yields the stated result when solved for the case of a dipole at the center. Equations for an eccentric dipole have also been derived by Wilson and Bayley (4), who used a method of Helmholtz (5), and by Frank (6), who used spherical harmonics. These equations also give the same result when solved for the centric dipole, if the higher order terms are neglected, and if the pole separation is small compared with the radius.

Craib (1) showed that when terrapin or rabbit hearts were placed at the center of a glass sphere, 11 in. in diameter, filled with Ringer's solution, the resulting potential field satisfied the dipole equations at points as close to the heart as one-third the radius for the terrapin heart and one-half the radius for the rabbit heart. Hartmann, Veyrat, Wyss, and Duchosal (7) showed that vectorcardiograms representing the entire heart could be obtained at points at a greater distance than at least two diameters of the heart. At points closer than this, presumably multipole representations (8) will be necessary.

Canfield pointed out that the magnitude and direction of the resultant dipole could be obtained from four po-

tentials on the surface of the sphere. Craib, however, apparently did not make use of this fact, for he was mainly concerned with testing the validity of the dipole hypothesis. The object of the present report is to show how the dipole moment can be determined from three bipolar measurements.

Assume a current dipole of magnitude  $M$  at the center of a sphere and with direction defined by the angles  $\alpha$  and  $\beta$  (Fig. 1). Angle  $\alpha$  is defined as the angle between the vector and the horizontal plane;  $\beta$  is the angle between the projection of the vector on the horizontal plane and the  $+x$ -axis. It is easily shown (9) that the potential at the surface on the  $+x$ -axis is given by

$$V_{+x} = \frac{3\rho}{4\pi R^2} M \cos \alpha \cos \beta + V_0 \quad (1)$$

where  $\rho$  is the resistivity of fluid in the sphere in ohm-centimeters;  $R$  is the radius of the sphere; and  $V_0$  is the additive constant. The units of  $M$  are milliampere-centimeters if  $V$  is expressed in millivolts, or microampere-centimeters if  $V$  is expressed in microvolts.

Also the potential at the surface on the  $-x$ -axis is

$$V_{-x} = -\frac{3\rho}{4\pi R^2} M \cos \alpha \cos \beta + V_0 \quad (2)$$

If  $E_x$  is equal to  $V_{+x} - V_{-x}$ , then

$$E_x = \frac{3\rho}{2\pi R^2} M \cos \alpha \cos \beta \quad (3)$$

Similarly,

$$E_y = \frac{3\rho}{2\pi R^2} M \cos \alpha \sin \beta \quad (4)$$

$$E_z = \frac{3\rho}{2\pi R^2} M \sin \alpha \quad (5)$$

From these, it is found that

$$\tan \beta = E_y/E_x \quad (6)$$

$$\tan \alpha = E_z/(E_x^2 + E_y^2)^{1/2} \quad (7)$$

If  $E_x$ ,  $E_y$  and  $E_z$  are measured,  $\alpha$  and  $\beta$  can be found from Eqs. 6 and 7, and the results can be substituted in Eqs. 3, 4, or 5 to find  $M$ .

If potentials are measured with respect to any point on the sphere, the potential of this point with respect to infinity can be designated  $V_0$ . When subtracting—for example, Eq. 2 from Eq. 1— $V_0$  drops out. The bipolar measurement of the three leads XX, YY, and ZZ is therefore sufficient for the complete determination of  $M$ .

The equations were first checked by means of artificial dipole experiments. Two different transparent plastic spheres, having diameters of 15.1 and 25.0 cm, were used for the measurements of the animal heart. Silver electrodes were mounted on the inside wall and projected through the wall in water-

Table 1. Magnitude and direction of peak vectors during QRS and T in six experiments on turtle heart.

Wave	M ( $\mu$ a-cm)	$\alpha$	$\beta$
QRS	64	-64°	96°
T	53	-22°	-51°
QRS	106	-71°	-98°
T	57	73°	28°
QRS	100	-22°	-12°
T	75	-9°	-143°
QRS	80	-50°	92°
T	66	-69°	17°
QRS	63	-48°	153°
T	33	-13°	-14°
QRS	80	-36°	128°

tight bushings. The bipolar leads were amplified and applied to an oscilloscope and photographed with a Grass moving-film camera.

Hearts were removed from painted turtles about 6 in. long and weighing about 700 g. The heart was suspended on a perfusion cannula at the center of the smaller sphere, and the sphere was filled with Ringer-Locke solution. By using Eqs. 3 to 7, spatial vectorcardiograms were obtained. On the basis of six experiments, the average peak vector for QRS was 82  $\mu$ a-cm, pointing downwards to the right (Table 1).

The T vectors were more variable, but generally pointed somewhat downwards and to the left; the average peak value was 57  $\mu$ a-cm. The maximum P vector was about 7  $\mu$ a-cm.

In four rabbit heart experiments in the larger sphere, the average peak value was 57  $\mu$ a-cm for QRS and 100  $\mu$ a-cm for T. Two main vectors were found, occurring at different times in the cardiac cycle. This sphere had elec-

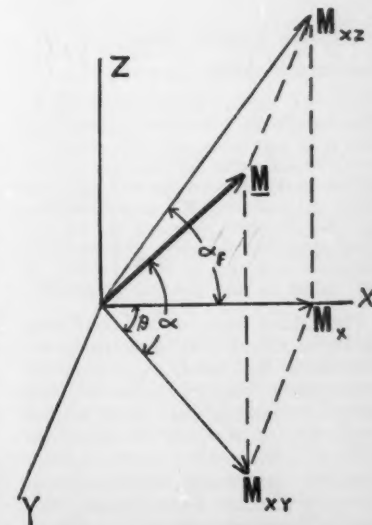


Fig. 1. Definition of coordinate system and angles.

trodes mounted at 30° intervals all over the inside wall, so that the heart vector could also be calculated by integration of the surface potentials (10). The simplified method was not as accurate, but gave a good approximation to the correct values (11). The data on the rabbit and turtle hearts are presented only to illustrate the nature of the results that can be obtained by the method described. The results suggested that there is a correlation between the weight of the heart and the magnitude of the peak vector (12).

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  12. Further experiments are in progress to study this relation and to obtain better statistical averages. This project was supported by grants from the U.S. Public Health Service (H-2590) and the Maine Heart Association.
- \* The author is an established investigator, American Heart Association.

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### Indole-like Urinary Stress Reactant in Man

**Abstract.** Paper chromatograms on extracts from serial 6-hr urine samples from humans of both sexes on indole-controlled diets revealed either the appearance of or marked increment in "spot 32" (1) after ACTH gel injections. This corresponds in time and duration with the rise in 17-hydroxycorticoid excretion. 5-Hydroxyindoleacetic acid and 28 other urinary indoles failed to show this rise predictably.

There have been several conflicting reports in recent years concerning abnormalities in indole excretion in schizophrenic patients compared with neurotic, "normal," or other control groups (2, 3). Kety, in his recent articles in *Science* (4), has speculated extensively concerning various systematic experimental errors which may account for these differences. It has been our general purpose to explore some of these "extraneous" factors in

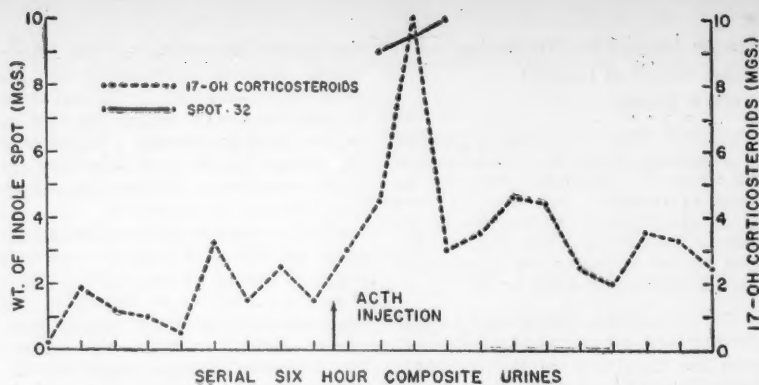


Fig. 1. A typical response of the indole-like "spot 32" and 17-hydroxycorticosteroids to ACTH gel injections. Spot 32 is visible down to a size corresponding to 6 mg weight. Spot 32 was not present except where indicated.

an effort to explain with documentation some of the findings reported in the area of indole research on schizophrenic patients. We are currently engaged in an evaluation of the effect of nonspecific stress factors on urinary indole excretion. This report presents a heretofore unreported phenomenon associated with activation of part of the physiologic stress mechanisms by ACTH injection—that of a predictable change in the excretion of indole-like compound.

Hospitalized neurotic, psychotic, and psychopathic patients who had not been on drugs were placed on a standardized, high-calorie, high-protein diet that was free of indoles except for the tryptophan contained in the protein (5). Twelve 6-hr urine specimens were collected before and nine after the intramuscular injection of 40 units of ACTH gel. Urinary extracts were made and chromatographed according to the method of Armstrong *et al.* (1) with the exception of the application of extract equivalent to 2 mg of creatinine for chromatography. The bidimensional solvent systems were isopropanol-ammonia-water (8:1:1) and benzene-propionic acid-water (10:7:5). 17-Hydroxycorticosteroids were determined by the method of Silber and Porter (6). The chromatograms were analyzed semiquantitatively by cutting out and weighing the spots. Using known indoles, we found, as did Masuda *et al.* (3), that there was a linear relationship between the amount of indole present and the size of the spot as indicated by its weight in the quantity range being measured.

Exogenous indoles from dietary sources due to previous uncontrolled food intake disappeared in 24 to 36 hr, resulting in relatively stable indole chromatograms from period to period except for the consistent diurnal variation (7). After the injection of 40 units

of ACTH gel, there was no predictable change in any of the 30 or more indole spots manifested by most patients with the exception of spot number 32. This spot was absent in pooled urines from the psychiatric staff and in most of the patients studied during the control period. It appeared usually between 6 and 12 hr after the injections and peaked in density and size during the period of maximum 17-hydroxycorticosteroid excretion (Fig. 1). It disappeared most commonly in 18 to 24 hr. Spot 32 failed to appear in those patients who, for some reason, did not respond to ACTH with a rise in excretion of 17-hydroxycorticosteroids. The appearance of this spot appeared to be unrelated to the diet, bowel status, or urinary volume and specific gravity. The response of this spot is probably unrelated to changes in the creatinine referent, because creatinine excretion did not change significantly with ACTH injection. The determinations of the 29 other indoles which likewise used creatinine equivalents of urine did not evidence this change predictably. In addition, its appearance was independent of age, sex, or diagnostic category of the subjects. Its  $R_f$  (0.07, 0.01), ultraviolet sensitivity, relative position, and development characteristics with *p*-dimethylaminobenzaldehyde suggest strongly that it is an indole or indole-like compound and is identical with spot 32 of Armstrong *et al.* (1). We are currently engaged in characterizing this response further by using corticoids, epinephrine, and psychological stress. Efforts are likewise being made to characterize this compound chemically.

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7. The individual indoles appear to manifest the same diurnal variation reported for 17-hydroxycorticoids and creatinine; they reach their peak in the morning hours and decline throughout the day and evening.

30 January 1961

### Standard for Reporting Concentrations of Deuterium and Oxygen-18 in Natural Waters

**Abstract.** A standard, based on the set of ocean water samples used by Epstein and Mayeda to obtain a reference standard for oxygen-18 data, but defined relative to the National Bureau of Standards isotopic reference water sample, is proposed for reporting both deuterium and oxygen-18 variations in natural waters relative to the same water. The range of absolute concentrations of both isotopes in meteoric waters is discussed.

In a previous report (1) the relationship between deuterium and oxygen-18 variations in meteoric waters throughout the world was shown. Many laboratories are measuring one or the other of these isotopes in various types of natural waters, and those workers studying  $O^{18}$  variations have more or less adopted, as a reference level for reporting enrichments, the "average ocean water" found by Epstein and Mayeda in the first precise work on  $O^{18}/O^{16}$  ratios in natural waters (2).

Deuterium analyses, however, occur in the literature relative to at least six different "working tap water" standards. In the previous report (1) the data presented for both isotopes showed how important it is to obtain data on both D and  $O^{18}$  variations in the same water samples, and it therefore seems that a common deuterium standard, preferably the same water as the  $O^{18}$  standard, should be adopted for consistency. The data shown previously (1) indicate that tap waters from various countries could easily differ by as much as 15 percent in the D/H ratio, and for many reasons it appears to be desirable to have an ocean water standard for reporting geochemical data.

For this purpose, the same set of ocean waters chosen by Epstein and Mayeda to give their "average ocean water" for  $O^{18}$  data was analyzed for the D/H ratio along with the samples described previously (1). These waters,

taken from depths of 500 to 2000 m in open ocean areas where no direct dilution by continental runoff or glacial melt water could occur, were grouped by Atlantic, Pacific, and Indian Ocean samples, and equal volume composites were made from each set and analyzed relative to the laboratory working standard.

No single sample of "average ocean water" which could be circulated widely for analysis actually exists. Oxygen-18 data have generally been tied to the Epstein-Mayeda scale by analysis of various carbonate samples, requiring special techniques for preparation of 100 percent  $H_2PO_4$ , and so on. However, in the course of the present work it was found that both the D and  $O^{18}$  data on the set of ocean waters analyzed could be very simply specified in terms of the National Bureau of Standards isotopic reference sample No. 1, a distilled water sample of large volume intended for cross-check circulation to mass spectrometric laboratories (3). After consultation with various laboratories it was decided to define a "standard mean ocean water" (SMOW) in terms of the National Bureau of Standards reference sample 1, such that

$$D/H \text{ (SMOW)} \equiv 1.050 D/H \text{ (NBS-1)}$$

$$O^{18}/O^{16} \text{ (SMOW)} \equiv 1.008 O^{18}/O^{16} \text{ (NBS-1)}$$

and to report isotopic data for both isotopes as per mil enrichments relative to the defined SMOW (4), thus tying the standard to a sample readily available for world-wide distribution.

The isotopic analyses of the composite ocean water sets made from the samples used by Epstein and Mayeda are shown in Table 1, in which the  $O^{18}$  data are averages for each set taken from their paper (2) with slight corrections later found necessary (5). The deuterium analyses are those I made, and all data have been calculated relative to SMOW, so that

$$\delta = [(R_{\text{sample}}/R_{\text{SMOW}}) - 1] \times 1000$$

is the per millage enrichment in either isotopic ratio  $R$ , relative to SMOW. The analytical precision has been described (1).

These data indicate that, within the limits of analytical precision and geographical variation, SMOW as defined above provides a consistent and convenient zero reference level for reporting isotopic enrichments and is an adequate average for the Epstein-Mayeda  $O^{18}$  data on "average ocean water." Clearly it will be a long time before the actual mean ocean composition is known; the designation "standard" indicates that SMOW is an arbitrary mean value based on the Epstein-Mayeda oxygen scale but defined in terms of an actual water reference standard, the NBS-1. The  $\delta O^{18}$  value of

Table 1. D/H and  $O^{18}/O^{16}$  enrichments of the Epstein-Mayeda "average ocean water" set and other samples, in per millage relative to SMOW. Numbers in parentheses after ocean names indicate number of samples in each set.

Sample	$\delta D$ (per mil)	$\delta O^{18}$ (per mil)
Atlantic (6)	- 0.7	+ 0.14
Pacific (11)	+ 0.9	+ 0.04
Indian (2)	+ 0.1	- 0.07
NBS-1	- 47.60	- 7.94
NBS-1A	-183.3	-24.33

the Chicago PDB-1 carbonate standard ( $CO_2$  from reaction with 100 percent  $H_3PO_4$  at 25°C) is +0.22 per mil on the SMOW scale (6).

Table 1 also shows the NBS-1 data as defined versus SMOW, and the value obtained for the NBS-1A secondary water standard. The D/H enrichment of NBS-1A relative to NBS-1 is found to be  $-142.5 \pm 2.5$  per mil (3). Horibe and Kobayakawa found a value of  $-141.3 \pm 2.3$  per mil (3,7) in good agreement. Their data yield an absolute D concentration for SMOW of  $157 \pm 1$  atomic parts per million (ppma), based on direct calibration with enriched standards. I analyzed five water samples which had been measured previously for absolute D content by Kirshenbaum (8); this comparison gives a D concentration of  $159 \pm 2$  ppma for SMOW. We may therefore take the absolute D content of SMOW as  $158 \pm 2$  ppma, corresponding to a D/H ratio of 1/6328.

Absolute  $O^{18}$  concentrations, based on data obtained by Nier and me, have been given for standards including the NBS-1 water (5). From these data the  $O^{18}$  concentration in SMOW is found to be  $1989.5 \pm 2.5$  ppma, corresponding to an  $O^{18}/O^{16}$  ratio of  $(1993.4 \pm 2.5) \times 10^{-4}$ .

In the previous paper (1) the relation between  $\delta D$  and  $\delta O^{18}$ , expressed as per millage enrichments relative to SMOW, was found to be linear in the majority of meteoric waters, obeying the equation

$$\delta D = 8 \delta O^{18} + 10$$

By using the absolute concentrations for SMOW as given above, the atom fractions of D and  $O^{18}$  are found to be related in meteoric waters by the expression

$$X_D = 0.6359 X_{O^{18}} - 1105.6$$

when the atom fractions are given in atomic parts per million. This relation is approximately obeyed by ocean waters also, but does not hold for lakes having high ratios of evaporation to outflow.

The total variations in meteoric waters are about 360 per mil for deuterium and about 48 per mil for oxygen-18, relative to the concentrations in SMOW. This variation in D content corresponds to a variation of about 6 ppm in density, while the  $O^{18}$  variation



corresponds to about 11 ppm in density. Thus the total density variation in meteoric waters produced by these isotopes is about 17 ppm, of which about 65 percent is due to  $O^{18}$ . The atomic weight variations in hydrogen and oxygen in these waters are about  $5.7 \times 10^{-5}$  and  $1.9 \times 10^{-4}$  atomic mass units respectively.

HARMON CRAIG

Department of Earth Sciences,  
University of California, La Jolla

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4.  $\delta D$  values have generally been reported in percentage, in contrast to all other stable isotope data which are given in per millage. However, as more laboratories begin to work on both isotopes, they will surely find it intolerable to work with enrichment ratios with two systems of units.
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6. I am greatly indebted to I. Friedman, S. Epstein, Y. Horibe, N. Kokubu, and H. C. Urey for discussions and suggestions on a consistent isotopic reference scale.
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18 January 1961

### Effect of Low Concentrations of Carbon Dioxide on Photosynthesis Rates of Two Races of *Oxyria*

**Abstract.** Alpine plants of *Oxyria digyna* have higher apparent photosynthesis rates at various carbon dioxide concentrations than arctic, sea-level plants of the same species. The ability to utilize carbon dioxide effectively at low concentrations may be involved in the survival of plants at high elevations.

The volumetric concentration of atmospheric carbon dioxide in parts per million varies little with altitude (1). On the other hand, the partial pressure of  $CO_2$  in the atmosphere decreases with altitude and with lowered total atmospheric pressure. As Decker (2) has pointed out, diffusion of  $CO_2$  into a leaf is a function of  $CO_2$  pressure. This has led to the suggestion (2, 3) that the altitudinal gradient of  $CO_2$  pressure may be an important factor in the zonation of plant species on high mountain ranges.

Since any possible effect of low  $CO_2$  pressure on alpine plant metabolism would be difficult to detect in the complex of environmental factors operating under field conditions, it is necessary to test this hypothesis under controlled conditions. In the laboratory, Decker (4) measured the effects of different  $CO_2$  concentrations (in parts per million) on apparent photosynthesis rates of plants from a lowland (elevation, 150

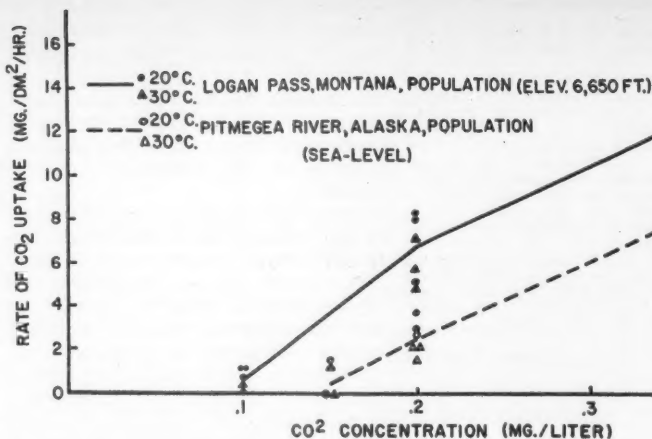


Fig. 1. Apparent photosynthesis rates of *Oxyria* leaves at low  $CO_2$  concentrations. Points are averages of two to four determinations on a single plant.

feet) clone of *Mimulus cardinalis* Dougl. and of a hybrid between this clone and a high elevation (10,700 feet) form of *M. lewisii* Pursh from the Sierra Nevada Range of California. The results of his experiments showed no consistent differences between the two clones in apparent photosynthesis rates at different  $CO_2$  concentrations and, thus, yielded no support for the hypothesis.

In our experiment we used plants of *Oxyria digyna* (L.) Hill, a wide-ranging, arctic-alpine herbaceous species whose photosynthesis rates are relatively well known (5, 6). The sea-level race was from the northern coastal plain of Alaska at the mouth of the Pitmegea River ( $68^{\circ}56'N$ ), while the alpine race was from Logan Pass, Montana ( $48^{\circ}42'$ ), at an elevation of 2027 m. The plants were all the same age (4 months), grown from seed (7) under controlled conditions of continuous photoperiod and alternating  $12.5^{\circ}C$  and  $1.5^{\circ}C$  thermoperiods of 12 hours each. Apparent photosynthesis rates were measured with an infrared gas analyzer by the techniques described by Mooney and Billings (6). Two to four determinations were made at  $20^{\circ}$  and at  $30^{\circ}C$  on single attached leaves of three plants from each race under 1850 ft-ca of light. As in Decker's method, the plant was allowed to reduce the  $CO_2$  in the dry air system from above 0.4 mg/lit. down to the compensation concentration, which was usually between 0.1 and 0.2 mg/lit. Results are expressed as averages of milligrams of  $CO_2$  uptake per square decimeter of one leaf surface per hour; they are shown in Fig. 1.

Throughout the entire range of  $CO_2$  concentrations at which apparent photosynthesis was measured, the plants from the alpine race were clearly more effective in fixing  $CO_2$ . Moreover, the compensation concentrations of the al-

pine race were not reached until near or below 0.1 mg of  $CO_2$  per liter. None of the plants of the sea-level race had any apparent photosynthesis at this low  $CO_2$  concentration, which approximates the  $CO_2$  tension at an altitude of 12,200 m. Even at a concentration of 0.4 mg/lit., which approximates the  $CO_2$  tension at 3000 m, plants of the sea-level race were only about 70 percent as effective photosynthetically as those of the alpine race.

While there was a slight tendency for plants of both races to be more effective at  $20^{\circ}$  than at  $30^{\circ}C$ , there was no clear-cut effect of temperature on apparent photosynthesis and compensation concentration as observed by Decker in *Mimulus*.

The data presented here appear to give substance to the hypothesis that low  $CO_2$  pressures may limit the upward distribution of plants of certain species and races on high mountain ranges (8).

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University, Durham, North Carolina

#### References and Notes

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4. J. P. Decker, *Plant Physiol.* 34, 103 (1959).
5. H. G. Wager, *New Phytologist* 40, 1 (1951); J. W. Wilson, *Ann. Botany (London)* 24, 372 (1960).
6. H. A. Mooney and W. D. Billings, *Ecol. Monographs* 31, No. 1 (1961).
7. Since it is not feasible to clone alpine *Oxyria* because they lack rhizomes (which arctic forms have), the plants used for measurement in both populations were randomly selected genotypes. Each plant has a recorded code number.
8. This work has been supported as a part of a grant (G 3832) from the National Science Foundation, Environmental Biology Program, for which we express grateful appreciation.

19 January 1961

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Why not instead send out a box of slides, a **Kodak Cavalcade Projector**, a decent tape recorder, and a **Kodak Cavalcade Programmer** that ties them together in a presentation so alive that your own living presence will scarcely be missed? The time saved could be devoted to new efforts—raw material for slides yet unborn. In return for forgoing the pleasure of your company as entertainer, society gets more out of you as investigator. This is a pretty bold suggestion; whether society has advanced enough to deserve it yet remains to be seen. Far better that we give only the facts and leave the visions to the customers.

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point in the discourse. Pertinent points about it may well occur to him that might not occur when speaking with his back to the picture and his gaze fixed on some vindictive-looking character in the fourth row. When he wants the next slide he presses the button again; without further human intercession the beep will change the slide at that instant every time. And so on for the allotted time. The "erase" feature of tape, a benign presence denied to those who speak in the flesh, is always comfortingly there during the recording session.

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# Meetings

## Radioisotopes in Entomology and Tropical Medicine

Two international symposia were held recently on the uses of atomic energy in medicine and entomology. These were convened and sponsored by the International Atomic Energy Agency (IAEA) and the World Health Organization (WHO). These United Nations organizations had as objectives the bringing together of specialists from all over the world to review the present state of research and the current uses of radiation and radioisotopes in medicine and entomology. Other objectives were to focus attention on medical and entomological problems in tropical areas and to stimulate new or additional research in various countries. An important aim was the bringing together of specialists with diverse technical backgrounds to give broad perspective, to introduce new and improved research techniques, and to stress the potential uses of radioisotopes.

At the invitation of the government of India, the International Atomic Energy Agency convened a "Symposium on Radioisotopes and Radiation in Entomology" in Bombay from 5 to

9 December 1960. Member countries of the U.N. were invited to send specialists to present papers and participate in discussions. Participants were sent by France, Germany, the Holy See, India, Italy, the Netherlands, Pakistan, the Philippines, the U.S.S.R., the United Kingdom, and the United States. Participants from the United States, invited and sponsored by the U.S. Department of Agriculture and the National Science Foundation, were B. W. Arthur, L. E. Brownell, J. E. Casida, T. L. Hopkins, and D. E. Weidhaas; D. W. Jenkins, the other U.S. participant, was sponsored by IAEA and WHO.

The symposium included sessions on the behavior of labeled insecticides in plants and animals, insect physiology and biochemistry, radiation effects and insect control, ecological and biological studies, and local problems in agricultural entomology. The present enormous loss due to insect damage to crops and stored grain and other agricultural products and to parasitism in domestic animals was emphasized in relation to the rapid increase in human population. Many outstanding accomplishments involving use of radioisotopes were presented, including elimination of the screw-worm fly in Florida by release of sterile males, development of new in-

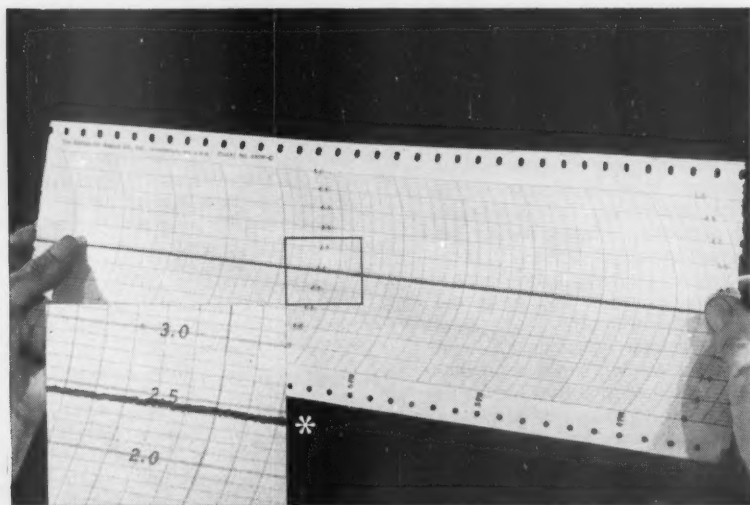
secticides, control of pests in stored products through irradiation, and use of lethal genes for control studies.

A "Symposium on the Use of Radioisotopes in the Study of Endemic and Tropical Diseases" was sponsored jointly by WHO and IAEA. This symposium was held at the invitation of the government of Thailand, in Bangkok, on 12 to 16 December. These United Nations organizations invited selected experts in tropical medicine and in the medical use of radioisotopes to present lectures and participate in discussions. Specialists were invited from Australia, Ceylon, Nationalist China, India, Iraq, Pakistan, the Philippines, Portugal, Sweden, Thailand, the Union of South Africa, the United Kingdom, the United States, Venezuela, and Vietnam. The invited speakers from the United States were H. H. Anderson, D. W. Jenkins, and J. B. Stanbury. The symposium was organized by joint scientific secretaries from WHO and IAEA. The scientific sessions were on nutrition, anemias, endemic goiter, electrolytes, entomology, and parasitology. In each session discussion of the major problems by a specialist was followed by papers on the use and potential use of radioisotopes and radiation. In active discussion, emphasis was placed on close relationships between areas such as nutrition, parasitism, and disease and on the need for broad and coordinated research programs. The continuing and urgent need for research to improve the health of people in the tropics was stressed. Atomic energy was shown to be of great value in medical and biological research in tropical areas, and outstanding accomplishments are expected.

The proceedings of the two symposia will be published by the IAEA and will be available from that organization in the near future.

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## Forthcoming Events

### July

1-3. Astronomical League, Detroit, Mich. (W. A. Cherup, 4 Klopfer St., Millvale, Pittsburgh 9, Pa.)

2-7. American Physical Therapy Assoc., Chicago, Ill. (Miss L. Blair, Executive Director, APTA, 1790 Broadway, New York 19)

2-9. Rural Medicine, 1st intern. congr., Tours, France. (Prof. Vacher, Secrétaire General, c/o Institut National de Médecine, Agricole, Ecole de Médecine, Tours)

3-6. Clay Minerals, colloquium on genesis and synthesis of, intern., Paris, France. (Prof. Hocart, Faculté des Sciences, Université de Paris à la Sorbonne, 47 rue des Ecoles, Paris 5)

3-8. Treatment of High Level Radio-



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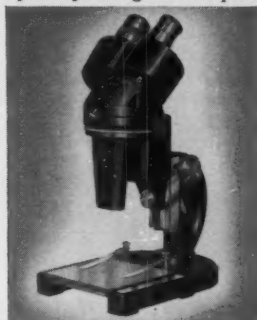
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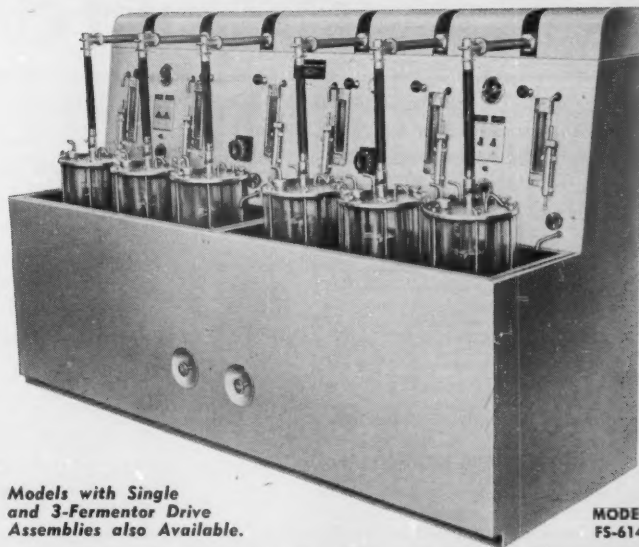
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3-16. Durability of Concrete, symp., Intern. Union of Testing and Research Laboratories for Materials and Structures, Prague, Czechoslovakia. (B. Hacar, Director, Inst. of Theoretical and Applied Mechanics, Czechoslovak Acad. of Sciences, Solnava 7, Prague 6-Dijvice)

4-8. Latin-American Assoc. of Physiological Sciences, 4th meeting, Ribeirão Preto, Brazil. (C. R. Diniz, Caixa Postal 301, Ribeirão Preto, Estado de São Paulo)

5-8. European Organization for Research on Fluorine and Dental Caries Prevention, 8th meeting, London, England. (J. R. Forrest, Senior Dental Officer, Ministry of Health, Savile Rd., London)

5-8. Optical Materials, colloquium, Intern. Commission for Optics, Paris, France. (Institut d'Optique, 3, Boulevard Pasteur, Paris 15)

5-9. International Convention on Radio Techniques and Space Research, Oxford, England. (British Institution of Radio Engineers, 9 Bedford Sq., London, WC.1)

5-12. International Ophthalmic Optical Congr., London, England. (G. H. Giles, Intern. Optical League, 65 Brook St., London, W.1)

6-7. Free Radicals, intern. symp., 5th, Uppsala, Sweden. (Symposium Secretariat, c/o Inst. of Physical Chemistry, Uppsala)

6-12. Agricultural Medicine, 1st intern. congr., Tours, France. (J. Vacher, Institut National de Medecine Agricole, Ecole de Medecine, Tours)

6-12. Ribonucleic Acids and Polyphosphates: Structure, Synthesis and Function, intern. colloquium, Strasbourg, France. (Prof. Ebel, Faculté de Pharmacie, Université de Strasbourg, Strasbourg)

9-14. Bio-Medical Electronics, 4th intern. conf., New York, N.Y. (H. Schwan, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia 4)

9-15. American Library Assoc., annual conf., Cleveland, Ohio. (D. H. Clift, 50 E. Huron St., Chicago, Ill.)

9-15. International Dental Federation, 49th annual session, Helsinki, Finland. (Office of Secretary General, IDF, 35 Devonshire Place, London, W.1, England)

10. Bibliographical Soc. of America, Cleveland, Ohio. (E. Wolf II, Library Co. of Philadelphia, Broad and Christian Sts., Philadelphia 47, Pa.)

10-14. Institute in Technical and Industrial Communications, 4th annual, Fort Collins, Colo. (Director, Inst. in Technical and Industrial Communications, Colorado State Univ., Fort Collins)

10-14. International Congr. of Dietetics, 3rd, London, England. (Miss D. F. Hollingsworth, British Dietetic Assoc. 251 Brampton Rd., London, S.W.3)

10-14. International Diabetes Federation, 4th congr., Geneva, Switzerland. (B. Rilliet, Secretary General, 4 Boulevard des Tranches, Geneva)

10-14. Optical Instruments and Techniques, conf., London, England. (K. J. Habell, Natl. Physical Laboratory, Teddington, Middlesex, England)

10-20. Plant Exploration and Introduction, technical meeting on, Food and Agriculture Organization of the U.N., Rome, Italy. (Intern. Agency Liaison Branch, Office of the Director General, Viale della Terme di Caracalla, Rome)

10-24. Medical Electronics, 4th intern. conf., New York, N.Y. (L. E. Flory, David Sarnoff Research Center, Princeton, N.J.)

11-25. World Meteorological Organization, 3rd South American session, Rio de Janeiro, Brazil. (WMO, 1 Avenue de la Paix, Geneva, Switzerland)

12-18. Radioactivity in Food and Agriculture, Expert Committee on the Organization of Surveys for FAO, Rome, Italy. (Intern. Agency Liaison Branch, Office of the Director General, Viale della Terme di Caracalla, Rome)

13-14. Data Acquisition and Processing in Biology and Medicine, conf., Rochester, N.Y. (Office of Public Information, Univ. of Rochester, River Campus Station, Rochester 20)

15-18. Life Insurance Medicine, 7th intern. congr., Lisbon, Portugal. (L. de Carvalho Cancellata, Secretary, Parede, Portugal)

16-18. British Congr. of Obstetrics and Gynaecology, 16th, Bristol, England. (Secretary, British Congr. of Obstetrics and Gynaecology, University Dept. of Obstetrics, Southmead Hospital, Bristol)

16-22. International Soc. for Clinical and Experimental Hypnosis, Rio de Janeiro, Brazil. (ISCEH, 33 E. 65 St., New York 21)

17-22. Soil Mechanics and Foundation Engineering, 5th intern. conf., Paris, France. (E. Caminade, Secrétaire General, 23 rue de Cronstadt, Paris 15)

(See issue of 19 May for comprehensive list)

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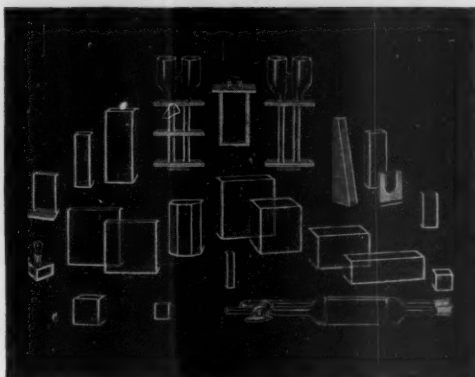
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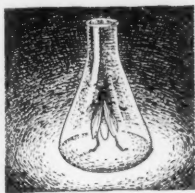
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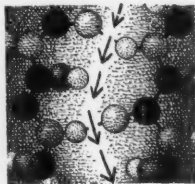
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a glance at yesterday in relation to today



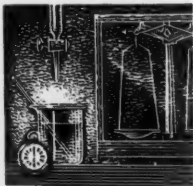
IN JUNE—(1801)—a paper read before the Royal Society describes some experiments and observations on “spontaneous light”. Herring, mackerel, and other objects “that abound with spontaneous light in the latent state” do not emit such light when deprived of life. Contrary to what other authors have alleged, oxygen does not render this light more vivid than it is in atmospheric air. Azotic gas, on the other hand, is favorable to spontaneous light and helps preserve its emission and brilliancy, while hydrogen, carbonic acid gas, and sulphurated hydrogen gas act to extinguish it.<sup>1</sup>

More refined methods now permit us to make more reliable observations of bioluminescence. No longer is it necessary to depend on herring or mackerel. Schwarz BioResearch has recently made available a Firefly Kit for convenient classroom demonstration of bioluminescence and for ATP assay. The Schwarz Firefly Kit provides 500 mg. of dehydrated firefly tails, 250 mg. of crystalline disodium ATP, plus comprehensive instructions and background information.



IN JUNE—(1880)—R. H. Chittenden reviews recent work on the enzymatic breakdown of albumin. “. . . it is plain that by the first step in digestion the albumin molecule is resolved into its two parts [antialbumose and hemialbumose], the gastric juice then readily changing the hemialbumose into hemipeptone, while the anti-group appears less susceptible to the action of pepsin, only a small portion of this group being changed into antipeptone, while the larger part, under the influence of the dilute acid, appears to be converted into partially insoluble products; but on reaching the intestinal canal these insoluble bodies, under the influence of the alkaline solution of trypsin, pass readily into solution and are digested with formation of antipeptone, which is readily absorbed, while the hemipeptone is further changed into crystalline decomposition products.”<sup>2</sup>

Today it is plain that many other proteolytic enzymes are involved in the digestion of albumin. Nevertheless, we still know almost nothing about the intermediate breakdown products. If you are studying the enzymic cleavage and synthesis of peptide bonds, you should have copies of two Schwarz catalogs: our regular catalog lists all the biologically important amino acids — plain and labeled with  $C^{14}$ ,  $N^{15}$ , and  $S^{35}$ ; a special catalog describes a long line of carboxy-amino acids, polyamino acids, polypeptides, and  $O^{18}$  — amino acid compounds produced by the Yeda Research and Development Company in Israel. Both catalogs are available upon request.



IN JUNE—(1949)—a group at Columbia publishes some new micromethods for the detection and determination of tissue hexoses. In 1946, Dische had described a new color reaction of hexoses with cysteine and other tissue constituents. Now, he and his associates have developed two modifications which promise to be of considerable value for the investigation of polysaccharides in animal tissues, body fluid, and bacteria and for measurement of blood galactose.<sup>3</sup>

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1. Hulme, N.: A continuation of the experiments and observations on the light which is spontaneously emitted from various bodies; with some experiments and observations in solar light, when imbibed by Canton's Phosphorus. Phil. Tr. Roy. Soc. London 91:403 (June 18) 1801. 2. Chittenden, R. H.: Report on progress in physiological chemistry, Am. Chem. J. 2:204 (June) 1880, 3. Dische, Z.; Shettles, L. B.; and Onos, M.: New specific color reactions of hexoses and spectrophotometric micromethods for their determination. Arch. Biochem. 22:169 (June) 1949.



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